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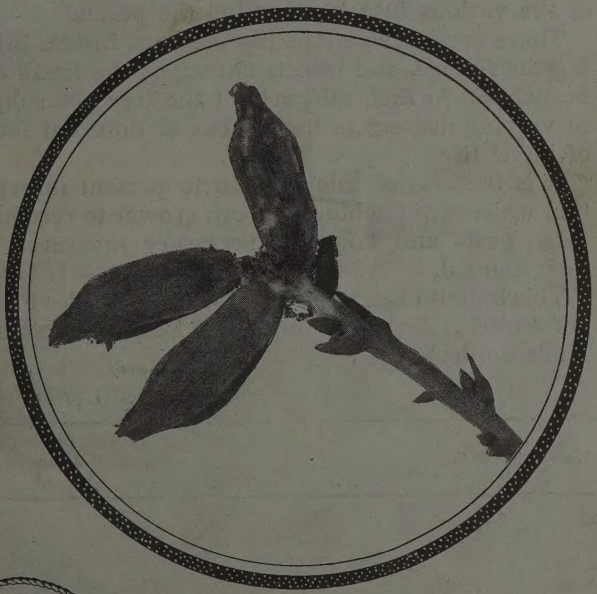
FARMERS' BULLETIN No. 1654

INSECTS *of the* PECAN *and how to* COMBAT THEM



1931

THE CULTURE of pecans in the South has developed rapidly in the last few years and is now looked upon as one of the great horticultural enterprises in that region. With this development has come an increase in the number and destructiveness of the various insects attacking the pecan.

There are insects attacking the nuts, insects injuring the foliage, and insects damaging the trunk and branches. In fact, all parts of the tree are subject in varying degrees to the attacks of different forms of insect life.

It is the aim of this bulletin to present information which will enable the pecan grower to recognize these pests and take the necessary measures for their control.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 1364, Important Pecan Insects and Their Control.

Washington, D. C. January, 1931

By 267

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INSECTS OF THE PECAN AND HOW TO COMBAT THEM[1]

xii, 324 W.

By G. F. Moznette, *Entomologist*, T. L. Bissell, *Assistant Entomologist*, and H. S. Adair, *Assistant Entomologist, Division of Deciduous-Fruit Insects, Bureau of Entomology*

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INSECTS INJURING THE NUTS

THE PECAN NUT CASE-BEARER

PERHAPS the most serious pest with which the pecan grower has to contend is the pecan nut case-bearer (*Acrobasis caryæ* Grote, formerly erroneously called *Acrobasis hebescella* Hulst). The successful control of this insect is one of the problems confronting the pecan industry. In its larval or "worm" stage it attacks for the most part the immature nuts, one larva often destroying several nuts before attaining its full growth, thus greatly reducing the crop in a severe infestation.

This insect has often been reported as destroying from one-third to three-fourths of the total crop of wild pecans in various localities in Texas. It is also present in Florida, southern Georgia, Alabama, Mississippi, and Louisiana, where it occasionally becomes a serious pest. In view of the large acreage of pecan orchards now bearing or coming into bearing, it probably will sooner or later prove a formidable pest throughout the greater part of the pecan belt.

[1] This bulletin is based in part on information contained in Farmers' Bulletin No. 1364, Important Pecan Insects and Their Control, by John B. Gill. Certain sections of the earlier bulletin have been incorporated in this bulletin with only slight changes; these include the sections relating to the pecan cigar case-bearer, pecan bud moth, fall webworm, walnut caterpillar, belted chion, and oak pruner. Many of the illustrations are the same as those used in Farmers' Bulletin 1364; in addition, a number of illustrations are credited as follows: Figure 1, J. B. Gill; Figure 21, A, H. G. Hubbard; Figure 21, B, A. W. Morrill; Figure 23, T. H. Jones; Figure 50, F. H. Chittenden; Figures 60 and 61, R. W. Leiby; Figure 70, T. H. Snyder.

NATURE OF INJURY

The small larvae that have passed the winter in tiny cocoons usually attached to the buds cause damage in early spring by attacking the tender shoots into which they tunnel. Many of these shoots wilt and turn brown and may be broken off by the wind. (Fig. 1.) Such injury is not serious as compared with the damage caused by the first and second generation larvae, which confine their attacks to the immature nuts.

FIGURE 1.—Pecan shoots showing spring injury by larvae of the pecan nut case-bearer

The first-generation larvae make their appearance in May and bore into the recently set nuts. At the point of attack they cast out pellets of frass or borings. (Fig. 2.) These borings are held together by means of fine silken threads, eventually forming a short silk-lined tube. Injured nuts always show the characteristic mass of frass protruding from the place where the larvae gained entrance, which is invariably near the stem end. The larvae of the second generation attack the nuts in the same manner as do those of the first generation, but the loss to the crop is not so great because of the size of the nuts at the time of attack. (Fig. 3.) Early in the season a single larva may destroy several nuts before attaining full

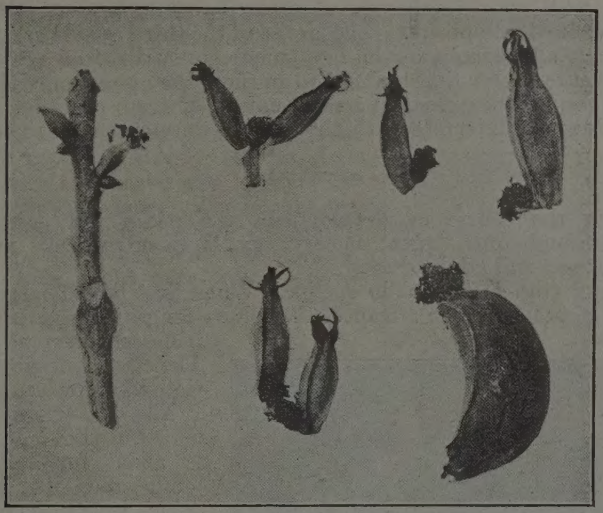

FIGURE 2.—Buds and young pecan nuts showing injury by larvae of the pecan nut case-bearer

FIGURE 3.—Cluster of pecan nuts infested by the pecan nut case-bearer

growth, while later in the season one or two nuts appear to be sufficient for its development. The larvae of the third generation, which make their appearance in the late summer, usually feed very little. They seem to prefer the shucks, and in these they gnaw only through the surface, forming small, narrow tunnels of frass particles. Such injury does not interfere with the normal development of the nuts.

DESCRIPTION

During the course of development the pecan nut case-bearer passes through four stages; namely, egg, larva or "worm," pupa or resting stage, and adult or moth.

The egg (fig. 4) is oval in outline. When first laid it is greenish white, but as incubation advances the color changes to a reddish tinge, iridescent in some lights. The eggs average one-fiftieth of an inch in length.

FIGURE 4.—Eggs of the pecan nut case-bearer. Enlarged 30 diameters

The full-grown larva or worm (fig. 5 at right) is about one-half inch long, and its general color is a dirty olive green. The body is sparsely covered with fine whitish hairs, and the skin is wrinkled. The head and mouth parts are dark brown, and the neck is pale brown.

The pupa or resting stage (fig. 5 at left) when first formed has a decided olive-green cast, but later is brown and without striking markings. It is about one-third of an inch long.

The moth or adult (fig. 6) is dark gray. The head and thorax are blackish gray. The forewings are gray and each has a ridge or tuft of long dark scales extending across it near the middle. The hind wings are much brighter than the forewings and without conspicuous markings. The abdomen is light gray. The moths measure from nine-sixteenths to twelve-sixteenths of an inch across the expanded wings.

SEASONAL HISTORY AND HABITS

Immature larvae of the nut case-bearer pass the winter in small tightly woven cases similar to those of the leaf case-bearer. (Fig. 32.) These cases are usually located where the buds join the stem and may be attached to either. Larvae become active in the spring, usually during the latter part of March or early in April, depending upon the season and latitude, and commence to bore their way

out. They at once attack the young tender shoots (fig. 1) and bore into them where a leaf joins the main stem.

The larvae feed within the pecan shoots for two weeks or more and then transform to pupae within their tunnels. After a pupal period which ranges from 11 to 18 days, the moths developing from the overwintering larvae appear usually between May 7 and 24, but here again the season and latitude influence the emergence. The emergence of the maximum number of moths coincides somewhat with the setting of the nuts. The dates given above are based on investigations near the southern boundary of Georgia.

FIGURE 5.—Pupa and larva of the pecan nut case-bearer: Pupa at left (enlarged 3 diameters), larva at right (enlarged 5 diameters)

The eggs are invariably deposited on the outer end of the nut, and usually at or near the base of the calyx lobes. From 7 to 10 days are required for the eggs to hatch. The first-generation[2] larva, immediately upon hatching, crawls about looking for a suitable place to spin a web. A protected place is chosen where it is convenient for the larva to enter a nut. This is usually where the nuts join to to make up a cluster. In making its flimsy web the larva attaches the strands of silken threads to a number of nuts and to the stem supporting the cluster. This silken inclosure probably serves as a protection from the attacks of predatory and parasitic insects while the larva is entering the small nuts.

Some of the larvae may begin feeding on the buds below the nut clusters, in the axils of the buds and stems, and later leave to attack the young nuts. The larva, whether small or practically mature, does not feed on the outer layers of the nut or bud; before entering, it bites out many small pieces and casts them aside, and does not begin to eat until its head is well imbedded in the tissues. These greenish-yellow particles of the outer layer, gnawed off by the larva in entering the nut, later make up part of the tubelike mass which is seen in Figure 2 protruding from the base of the nuts. This has been called a case, although it is not a true case like that constructed in the

FIGURE 6.—Moth of the pecan nut case-bearer. Enlarged 4½ diameters

[2] In discussing the life history of a species a generation is considered to begin with the egg stage and to end with the adult or moth.

spring by the pecan leaf case-bearer. The greenish-yellow particles of the outer layer may be readily distinguished from the remainder of the tubelike mass which is composed of darker colored particles of excrement.

The larva as it feeds in the nut stops occasionally to line the mass of frass and excrement with silken threads. Often the tubelike mass may extend so far out that it joins another nut and is attached to it by the larva. In entering each succeeding nut attacked, the larva goes through the same process, not consuming any of the outer layer. The tubelike mass of frass, being attached to several small nuts, serves as a protection to the larva by holding the nuts together in the cluster and preventing them from dropping to the ground.

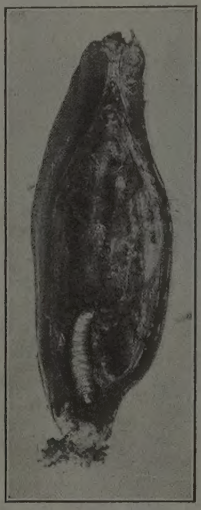

FIGURE 7.—Pecan nut infested by larva of of the pecan nut case-bearer

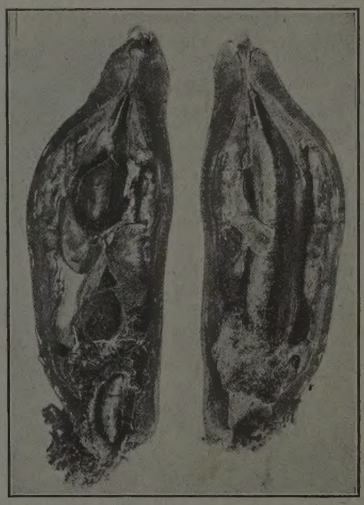

FIGURE 8.—Opened pecan nut showing location of the pupa of the pecan nut case-bearer

A larva of this brood feeds in from two to five nuts during the larval period, which lasts from 22 to 29 days. Upon reaching full growth the larva pupates or transforms to the resting stage within one of the small nuts which it has hollowed out. The pupal period of this generation is from 9 to 13 days. All of the moths in a large series under observation during 1914 to 1917 emerged during the period from June 11 to July 16, but the maximum emergence occurred during the last week in June. The eggs deposited by these moths are also laid upon the nuts.

Most of the second-generation eggs hatch during the last week in June and the first 10 days of July. The larvae of this generation likewise feed within the nuts. (Fig. 7.) The average length of the larval stage for the second generation is 25 days, and the pupal period averages about 10 days. Pupation takes place within an

infested nut (fig. 8), and most of the moths of the second generation appear during the first three weeks in August. At Brownwood, Tex., it has been observed that upon hatching some of the larvae of this generation migrate to the leaves to do their first feeding and later attack the nuts. Some of the larvae of this generation, after feeding a little, may construct their hibernation or winter cases and go into the dormant condition.

The larvae of the third generation feed lightly upon the shucks and do little or no damage to the nuts, which usually are beginning to harden at this time. The larvae do not mature now, but after feeding for a time they leave the nuts to construct their hibernation cases. Usually there are but three generations of this insect in a year. At Brownwood, Tex., four generations have occurred in some years. At that place the third and fourth generation larvae feed to some extent on the leaves and tender shoots as well as on the shucks.

The approximate time of the different stages and activities of the pecan nut case-bearer in northern Florida are shown in Figure 9. The periods, however, will vary according to the locality and season.

CONTROL

Considerable study has been devoted to the problem of controlling the pecan nut case-bearer, but no satisfactory control measures can be recommended. Lead arsenate, alone and in various mixtures, has been recommended for this pest and is still being recommended by some investigators. The results obtained by spraying have been somewhat variable, and in most instances the degree of control has not been very marked. Some pecan growers who have used lead arsenate against this pest have not met with success after several years of trial and have discontinued its use.

The feeding habit of the larva makes it difficult to control this insect by spraying with lead arsenate. As the larva does not consume the outer layers of the nut bearing the insecticide, it is natural to assume that the larva will escape getting the poison.

Laboratory experiments which were made in conjunction with field experiments showed that lead arsenate applied to clusters of nuts either as a dust or spray did not deter the larvae from entering, and they seemed to pay little attention to its presence on the clusters, as was shown by the rapidity with which, in most cases, they commenced feeding after being placed on clusters of small nuts. The larvae went through the same process of casting aside the bites of the outer layers whether the nuts were treated or not.

Therefore, before there can be any hope of killing this larva with a stomach poison, some poisonous substance must be found which the larva will consume. An ideal poison would be one which the larva prefers to its normal food.

Traps and attractants: Some mention has been made in the past in various publications concerning the attraction of adults of the pecan nut case-bearer to sweetened mixtures. Such articles have usually been published by growers who have claimed great success for the method. The writers have experimented extensively, both at Thomasville, Ga., and Brownwood, Tex., with the following sub-

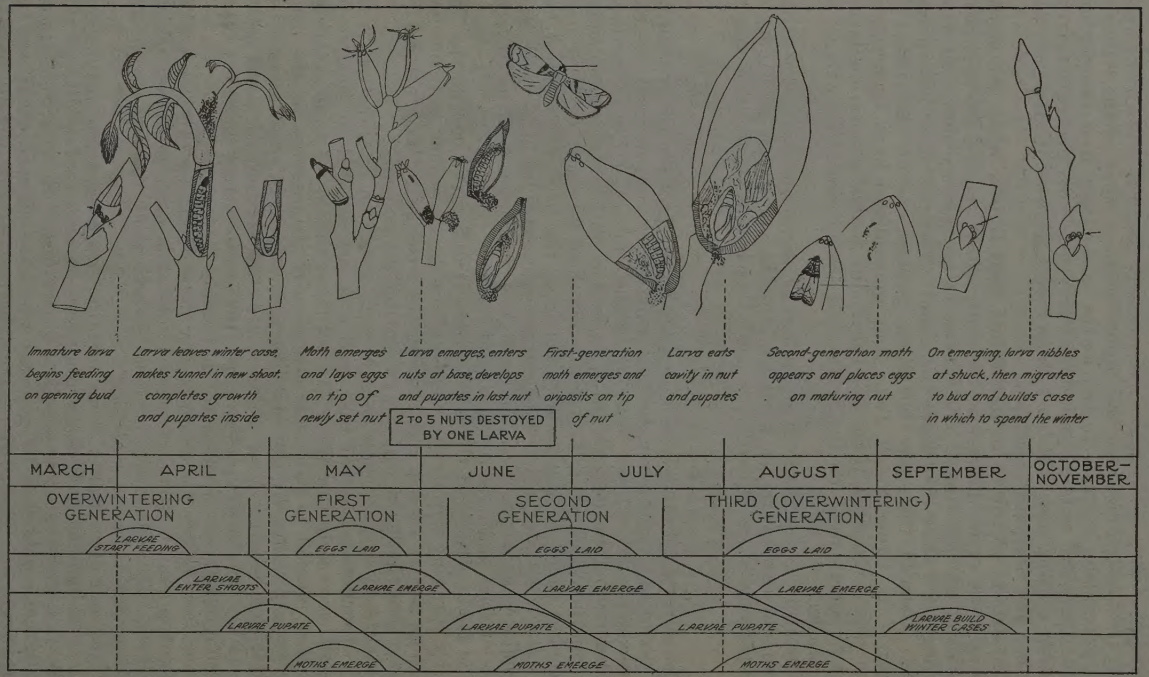
Immature larva begins feeding on opening bud
Larva leaves winter case, makes tunnel in new shoot, completes growth and pupates inside
Moth emerges and lays eggs on tip of newly set nut
Larva emerges, enters nuts at base, develops and pupates in last nut
2 TO 5 NUTS DESTOYED BY ONE LARVA
First-generation moth emerges and oviposits on tip of nut
Larva eats cavity in nut and pupates
Second-generation moth appears and places eggs on maturing nut
On emerging, larva nibbles at shuck, then migrates to bud and builds case in which to spend the winter
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER–NOVEMBER
OVERWINTERING GENERATION
FIRST GENERATION
SECOND GENERATION
THIRD (OVERWINTERING) GENERATION
LARVAE START FEEDING
EGGS LAID
EGGS LAID
EGGS LAID
LARVAE ENTER SHOOTS
LARVAE EMERGE
LARVAE EMERGE
LARVAE EMERGE
LARVAE PUPATE
LARVAE PUPATE
LARVAE PUPATE
LARVAE BUILD WINTER CASES
MOTHS EMERGE
MOTHS EMERGE
MOTHS EMERGE

FIGURE 9.—Seasonal history of the pecan nut case-bearer

stances: Cane sirup, honey, corn sirup, molasses, and vinegar and molasses, to which small quantities of sodium arsenite were added. These were diluted with water at the following strengths: 1 to 10, 1 to 20, and 1 to 50. Three types of containers were used, 2-quart tin buckets, 1-quart Mason jars and 2-quart stew pans. In placing the containers, one was put in the upper part of a tree and one in the lower. These traps were maintained in the trees at various times throughout the period of emergence of moths of the different generations.

The results have been very disappointing, for in no case was a case-bearer moth attracted to the mixtures tried. It is true that many moths of other species, particularly those which breed on grasses and weeds, were caught, but the pecan pests did not come to the traps. Instead, some of the beneficial forms which prey upon various pecan insects were captured.

A series of similar experiments was also tried at Thomasville, Ga., and Monticello, Fla., in which many aromatic chemicals were used as attractants, and up to this time the results have been similar to those obtained with sweetened mixtures. Further investigations along this line are in progress, but until experiments have proved conclusively that this species can be attracted to various mixtures, it is suggested that pecan growers spend their time and money in some other way.

Parasites: A good many growers have no doubt thought at various times of natural enemies in relation to the control of the pecan nut case-bearer. When a pecan grower sees his developing pecans destroyed by the hungry larvae of this pest, he is apt to long for a miracle to remove the plague from his orchard. Sometimes the "miracle" takes place, and many case-bearers never mature to lay their eggs for another generation. Such assistance is frequently given by certain kinds of insects commonly known as parasites. Some of these little friends of the grower live within the bodies of the insects which they attack, called their hosts, where they pass their entire larval existence, while others live externally upon their hosts.

The pecan grower is not without these minute, friendly insects. At Albany, Ga., and Brownwood, Tex., where the Bureau of Entomology maintains laboratories for the investigation of the various pecan insects, a number of parasites of the pecan nut case-bearer have been reared.

The work of all true parasites is rather spasmodic because of the very nature of their existence. Naturally, when they cause a decrease in the numbers of the hosts, the parasites die from lack of food and may be so reduced in numbers that they are not able at a subsequent time to check a rapidly increasing number of the hosts, and a serious infestation may result.

THE HICKORY SHUCK WORM

During the fall a small white larva or worm (fig. 10, right), about three-eighths of an inch in length, may be found mining the shucks of pecan or hickory nuts. This larva is commonly referred to as the hickory or pecan shuck worm (*Laspeyresia caryana* Fitch). The mining or tunneling of the shucks often results in the improper

development of the nut kernels and prevents the natural separation of the shucks from the nut shells. Nuts infested by shuck worms are often undersized and later in maturing than those free from this pest. The damage is not restricted entirely to the matured nuts, for in the spring and early summer the larvae destroy the small, green nuts by eating out the interior. Injury of this type is not so noticeable as that caused in the fall, but it should not be minimized, since investigations have shown that it plays no small part in the reduction of the nut crop.

Besides attacking the pecan, this insect feeds upon the nuts of various species of hickory, where the injury it does is similar to that on the pecan, except that the destruction of the small, green nuts seems to be greater. Occasionally the larvae will be found subsisting on the galls formed by certain species of Phylloxera (*Phylloxera caryaecaulis* Fitch, *P. devastatrix* Pergande).

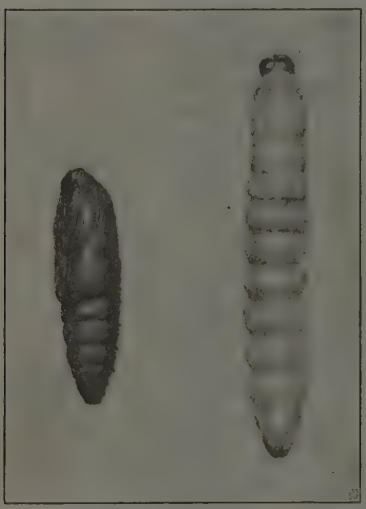

FIGURE 10.—Pupa and larva of the hickory shuck worm: Pupa at left, larva at right. Enlarged 6 diameters.

DESCRIPTION

The shuck worm passes through the same four stages in its development as the pecan nut case-bearer: Egg, larva, pupa, and adult or moth. The moth (fig. 11) is smoky black, mixed with iridescent bluish and purplish tinges, and the forewings have a series of short, yellowish streaks across their front margins. The moths are rather variable in size, but the width across the wings is rarely more than three-fifths of an inch. Because of their protective coloration the moths are seldom noticed in pecan orchards, even by keen observers.

The egg is small, whitish, and more or less oval, and under high magnification its surface is seen to be wrinkled.

The larva upon emerging is a very small, whitish, 16-footed worm. When full grown it is about three-eighths of an inch in length and has a creamy-white body and light-brown head. (Fig. 10, right.)

The pupa (fig. 10, left), which is brownish, is always found within the infested shuck.

SEASONAL HISTORY AND HABITS

In the greater part of the pecan-growing region the hickory shuck worm probably has two generations a year, and in the extreme southern part of the region it apparently has four generations, whereas in the Northern States, where the insect subsists on various species of hickory, there is perhaps only one generation. The moths, which

develop from larvae that spend the winter in the fallen pecan or hickory shucks, begin to appear in northern Florida as early as the middle of February. The maximum emergence of moths in that section occurs during the last two weeks of March. Experiments conducted during 1928 and the early part of 1929 have shown that all of the larvae may not transform and emerge during the spring, and larvae may be found in the shucks on the ground and in those buried in the soil during the year. There may be emergence throughout the summer. In some years a few may remain as larvae through a second winter before transforming and emerging.

FIGURE 11.—Moth of the hickory shuck worm. Enlarged 2½ diameters

Most of the moths come out before the appearance of the pecan foliage and nuts, and this apparently accounts for the extremely small numbers of first-generation larvae that attack the pecan trees. The development of the foliage and nuts of the pignut (*Hicoria glabra* Mill) and the Mockernut (*H. alba* L.) is much earlier in the spring than that of the pecan, and it seems that the emergence of moths is timed for these host plants. Considerable damage is always done to the very early small hickory nuts by the first-generation larvae, while the very small pecan nuts seem to escape such injury. Some first-generation larvae will be found attacking the tender shoots

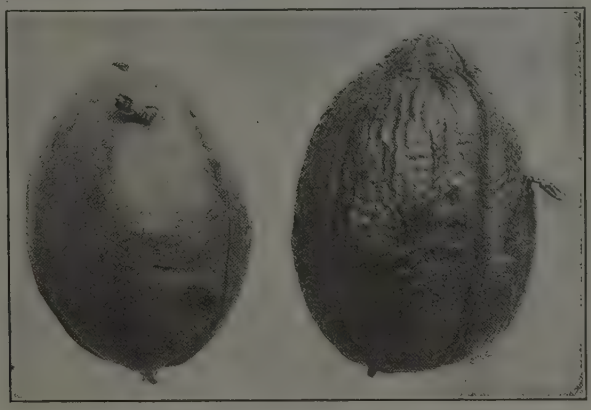

FIGURE 12.—Pupal skins of the hickory shuck worm protruding from shucks of pecan nuts

of pecan, but the apparent reason for the immunity from attack of the recently set pecan nuts is the fact that the emergence of the moths does not coincide very well with the development of the nut.

The moths deposit their eggs on the young nuts or foliage, and during the summer months the period of incubation lasts about five days. Upon emerging the larvae gnaw their way into the nuts by making pinhole entrances and proceed to mine the shucks of the nearly mature nuts, but in early summer the larvae bore into the

interior of the green nuts and cause them to drop to the ground. During the spring and summer the larvae usually feed from three to four weeks, and transform to pupae within the green nuts or the shucks of matured nuts.

The length of the pupal period ranges from 9 to 45 days. During the summer months it lasts about 11 days, while most of the pupae from overwintering larvae transform to moths in 18 days, although some few moths do not issue for a considerably longer period. The pupation of the overwintering larvae usually takes place in considerable numbers between the first of February and the middle of April.

Before transforming to the pupal stage the larva prepares a small silk-lined cocoon, and cuts a circular hole to the outside of the shuck, which facilitates the escape of the moth. Just before the emergence of the moth the pupal skin is extended a short distance through the circular cut (fig. 12), the lid of which remains attached to the nut in a sort of trap-door arrangement.

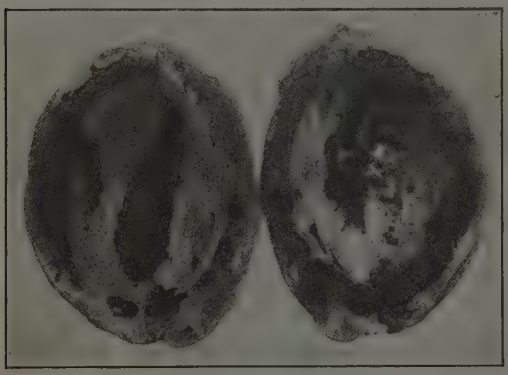

FIGURE 13.—Injury to matured nuts caused by the hickory shuck worm

As stated above, the larvae of the first generation feed for the most part on small hickory nuts, but during the last days of June and through July and August, although continuing their depredations on the hickories, the larvae will be found attacking the green pecan nuts. The first and second generation larvae destroy the interior of the nuts and invariably cause them to drop. The last generation larvae, which attack the nearly matured nuts with hard shells (figs. 13 and 14), feed only on the shucks, in which they mine and attain full growth before the advent of cold weather. They pass the winter as larvae in the shucks on the ground or in shucks that remain on the trees.

CONTROL

There are a number of parasites which attack the shuck worm and aid in the destruction of the species, but usually they are not abundant enough to control the insect.

Since the insects pass the winter as larvae in the shucks, it seems that the best method toward control known is to gather and destroy all shucks; this should be done during harvest or immediately after if possible, and not later than the middle of February. To bring about effective control by this method, the removal of the shucks from the orchard must be very thorough. Some growers prefer harvesting their pecans by means of bamboo poles, whipping the

nuts onto sheets stretched beneath the trees. In this way many of the loosened shucks may be collected and gathered into piles in the orchard and burned, and this will help to keep the numbers of the shuck worm down. Plowing under the shucks is not effective, as larvae covered from 2 to 4 inches have been found to come up to the surface of the soil, transform, and emerge as adults. The success of the plowing method depends wholly upon the burying of the pupae within the shucks. Since the larvae leave the buried shucks and the period of pupation extends over such a long time, plowing is of but little value as a control measure.

Hickory trees growing adjacent to pecan orchards will always prove a source of infestation by this pest as well as certain other injurious insects. It would seem, therefore, that the removal of hickory trees from the immediate vicinity of the orchards would be a very good procedure.

FIGURE 14.—Larva of hickory shuck worm in shuck of nearly matured pecan nut. Enlarged 2 diameters

THE PECAN WEEVIL

The pecan weevil (*Curculio caryae* Horn), sometimes called the hickory nut weevil, is in some sections a serious hindrance to the successful culture of pecans. It has long been encountered in the native pecan groves of Texas and Louisiana and is well known in the cultivated orchards of the more elevated areas in the eastern part of the pecan belt. In Georgia and Alabama injury is largely confined to the piedmont region, although the insect is known to occur in pecans in the extreme southern portions of those States. Like many other insects, the pecan weevil causes much more damage in some years than in others, but in its range this pest can be counted on to bring considerable loss to pecan growers.

Schley and Stuart pecans are the most subject to attack, evidently because these are among the earliest varieties to form kernels. The weevil also breeds in hickories over the pecan belt and occurs as far north as New York on some species. This affinity for hickories makes the problem more difficult for pecan growers, as there is a

direct relation between the abundance of hickory and wild pecan and the severity of weevil infestation of cultivated pecans in the same locality.

NATURE OF INJURY

The first injury of the season occurs when adult weevils appear in the trees and puncture the nuts before the latter have passed the "water stage," that is, before the kernel has formed within the nuts. Injury by weevils at this time causes the nuts to shrivel, turn dark inside and out, and usually fall in a few days. This darkening of the nuts has been called "black pit," a malformation which is also caused by certain other insects and probably by mechanical injury such as the beating of twigs against nuts in a high wind. A much better known injury by the weevil is the destruction of nuts in the fall by grubs or worms which are the young of the weevil. Activity of this insect in an orchard is disclosed by holes in the mature nuts

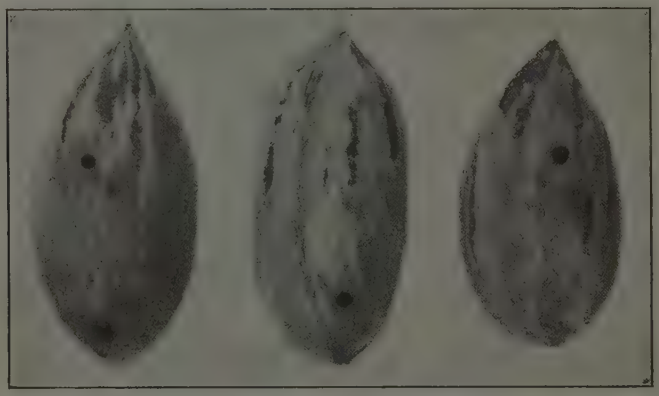

FIGURE 15.—Exit holes of larvae of the pecan weevil

(fig. 15) made by the emergence of full-grown larvae. The hole is round and about one-eighth of an inch in diameter. Infested nuts can also be distinguished before the larvae issue from the fact that the shuck fails to separate from the shell at the time when normal nuts are ripening.

DESCRIPTION

The adult of the insect is a dark-brown weevil with pale-brown or gray scales; it has awkward legs and an extremely long slender beak. (Fig. 16.) The beak of the female measures one-half of an inch, or about one-eighth of an inch longer than the body; that of the male is shorter than the body.

The egg, which is capsule shaped or irregular in form, is one thirty-fifth of an inch in length. It is smooth and clear. The immature larva is white. The mature larva (fig. 17) is a fat yellowish grub with a small reddish-brown head and without legs. It is

three-eighths to one-half of an inch long. The pupa is white and, having no covering, shows the developing appendages of the adult into which it transforms.

SEASONAL HISTORY

Adult weevils emerge from the ground during the summer, and both males and females feed by puncturing immature pecans and hickory nuts and drawing juices from the center. In 1928 the weevils emerged near Barnesville, Ga., from July 12 to September 15. The height of emergence came after heavy rains in the middle of August. Emergence during 1927 occurred somewhat earlier. Mating and oviposition begin in the latter part of August or first of September and continue about one month. Though punctures are made in nuts as soon as weevils start emerging, eggs are not laid until nuts can be found with well-developed kernels. The shells at this time are nearly hardened. When laying eggs, the female first drills a hole (fig. 18) through the shuck and shell with her long beak, at the end of which are two minute teeth. From this center she drills holes into the kernel in different directions, some going deep into it, some turning upward to the shell.

FIGURE 16.—Adults of the pecan weevil: Male at left, female at right. Enlarged 2½ diameters

Hickory nuts have been found with all the eggs laid in little pockets in the outer skin of the kernel in a ring around the one puncture which passed through the shell. Eggs may be placed in the solid part of the kernel or in the fissure or narrow open space in the very center of the nut. The eggs are laid one at a time in the puncture and pushed to their places, probably with the aid of the beak. Two to six eggs have been found laid through one puncture. Rarely is more than one puncture made in a nut for egg-laying, and apparently weevils shun nuts which have already been punctured. The eggs hatch in a week, and the grubs find a rich supply of food at hand and become full grown in one month. Thereupon they leave the nuts by cutting a hole through the shell and shuck and immediately enter the soil under the tree. The larvae penetrate to a depth of 1 to 9 inches and form regular cells by pressing back the surrounding earth. Apparently a heavy compact soil is essential to the formation of these cells. Larvae go somewhat deeper in cultivated than in uncultivated soils. In a hickory forest they go to a depth of 1 to 5 inches or an average of 3 inches, while in a culti-

vated pecan orchard they go as deep as 9 inches, though most of them are found about 6 inches below the surface.

The mature larvae issue from nuts beginning the latter part of September through November and have been observed to emerge as late as January. Most of them leave the nuts during October. Lar-

FIGURE 17.—Grubs or larvae of the pecan weevil within the nuts

vae live in their underground cells without feeding. Pupation takes place in the bare cell the first or second fall after leaving the nut. In about one month the pupa changes to adult and the latter forces its way up through the ground the following summer. Thus there is an overlapping of generations. Some weevils emerge the second year and some the third year after entering the ground as grubs. Probably most of them require three seasons for development.

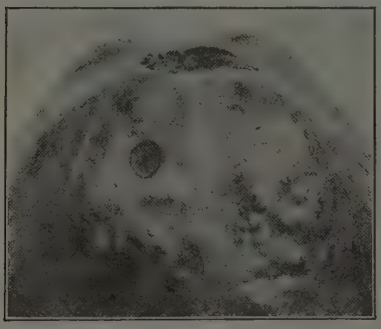

FIGURE 18.—Egg puncture of the pecan weevil in pecan shuck. Enlarged 3 diameters

CONTROL

No adequate means for control of the pecan weevil has been perfected, but a number of measures may be suggested to curb its destructiveness. The first is the elimination of hickories where this is practicable. Do not set out an orchard in the vicinity (say one-half mile) of hickory forests, as these breed hosts of recruits to infest pecan nuts.

Another measure is to gather nuts from trees before the larvae have had time to leave them and destroy these larvae before they reach the soil to burrow and complete their development. This requires making an early harvest. The latter part of September examine trees of susceptible varieties, Schley and Stuart, for weevil infestation. As stated before, on all nuts which have been attacked, the shucks fail to open. Cut open some of these and see if they contain grubs. Some shucks fail to open from other causes, as shuck-worm

damage, underdevelopment, and early frosts, so the only certain way to make diagnosis is to find the grubs. Some trees will be found much more heavily infested than others, even of the same variety and on adjoining rows, and accordingly every tree should be examined. With severely infested trees the most satisfactory procedure is to thresh off all nuts before the grubs begin to issue and place them in tight-bottomed containers to keep the grubs from reaching the ground. Later, after the period of emergence is ended, the non-infested nuts can be graded out. This early gathering will entail considerable extra work, as the green nuts are not readily knocked from the trees, but if nothing is done until the regular time for harvest it will be found that practically all larvae have emerged from the nuts and gained access to the soil.

Thorough cultivation of pecan orchards doubtless aids in weevil control. Some stages of the weevil can be destroyed by exposing them to the weather and their natural enemies. The grubs are little affected by cultivation, for when turned to the surface they at once burrow again and make new cells. The pupae and adults, however, are helpless when taken from their cells and can not dig below the surface. Deep plowing, at least 7 inches in clay or clay loam, in the winter or spring will help to kill the adults which would normally emerge during the ensuing summer. Hogs and chickens, if confined to the orchard, will destroy many insects turned up by the plow.

THE SOUTHERN GREEN STINKBUG AND OTHER PLANT BUGS

BLACK PIT AND KERNEL SPOT

Black pit and kernel spot of the pecan are manifestations brought about by the feeding of sucking insects upon the immature nut. They are well known over the pecan belt and, though not considered major problems, occasionally become quite serious to an individual grower. They are found to recur irregularly in restricted sections, being abundant one year and practically absent the following. Both of these troubles were first thought to be caused by fungi, but it has been shown that they are caused by the feeding of the southern green stinkbug (*Nezara viridula* L.) (figs. 19 and 20) and some closely related species.[3] (Fig. 21.)

Black pit is a discoloration of the interior of the green pecan. The affected nuts always drop prematurely. Much of the midsummer drop often attributed to other causes is probably due to black pit caused by the feeding of these sucking insects. The only outside evidence noticeable before the nuts fall is a brown stain on some of the nuts caused by the juice coming through the small hole made by the puncture of the insect. The first sign of damage to attract the pecan grower's attention is the dropping of the nuts in early summer. The affected nuts sometimes show brown or black spots on the shuck; these often spread over the entire surface soon after the nuts drop.

These sucking insects commence feeding on the nuts when quite small, probably the middle or latter part of June, and continue until the nuts are practically mature. However, the punctures made after

[3] *Leptoglossus phyllopus* L., the leaf-footed bug; *L. oppositus* Say, the northern leaf-footed bug; and *Euschistus euchistoides* Voll.

the nuts are past the water stage do not produce black pit but instead a condition known as kernel spot.

Pecan kernel spot [4] consists of dark-brown or black spots of variable size on the kernels of the nuts. (Fig. 22.) Upon the central portion of each spot is found a small pimplelike structure, which marks the entrance of the insect's beak. A magnified cross section of the center of a spot shows rupturing of the epidermal cells and those cells lying immediately beneath, a condition which seems to be caused by the extraction of the oil and other substances from that portion of the kernel. An affected kernel may have several spots, varying in diameter from one-sixteenth to three-sixteenths of an inch. Although the surface of the spot is dark, the internal part is whitish. The spots are pithy and porous and are decidedly bitter, but this bitter taste does not seem to be imparted to the unaffected portion of the kernel. This injury can not be detected until after removing the shells, as there are no discernable signs of insect injury on the outside of the shell of fully-matured nuts. On immature nuts, however, the punctures may be seen if examined closely, as the shell is whitish until the nut enters the ripening or maturing stage. Usually there is also a slight depression or pit in the shuck at the point of entrance of the insect's beak.

FIGURE 19. — Southern green stinkbug. Enlarged 4½ diameters

DESCRIPTION AND LIFE HISTORY OF THE SOUTHERN GREEN STINKBUG

As the habits of the various species of plant bugs which cause black pit and kernel spot are quite similar, only the southern green stinkbug will be described. The southern green stinkbug is usually of a light-green color, with the upper surface somewhat darker than the under surface. Adults collected during the colder months of the year, however, are usually much darker, with a purplish or pinkish tinge. The adult is shield shaped, which is the characteristic form

[4] For a more complete account of pecan kernel spot see U. S. Department of Agriculture Bulletin 1102, Kernel Spot of the Pecan and Its Cause.

of the members of the stinkbug family. The upper surface of the body is slightly convex, while the lower surface may be termed strongly convex. It measures about one-half of an inch in length. When disturbed or handled, the adults give off a strong disagreeable odor, and on account of this habit the name "stinkbug" is applied to this species as well as to many closely related forms.

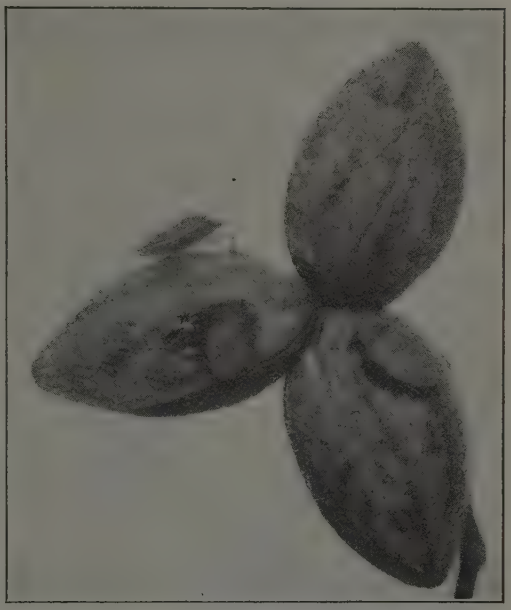

FIGURE 20.—Southern green stinkbug on pecan nuts of the Curtis variety

The southern green stinkbug passes the winter in the adult stage, often leaving its winter quarters during periods of mild weather. Egg laying does not begin until early in April and may continue until the middle of November. The eggs (fig. 23) are laid in clusters on the underside of the foliage, and during the

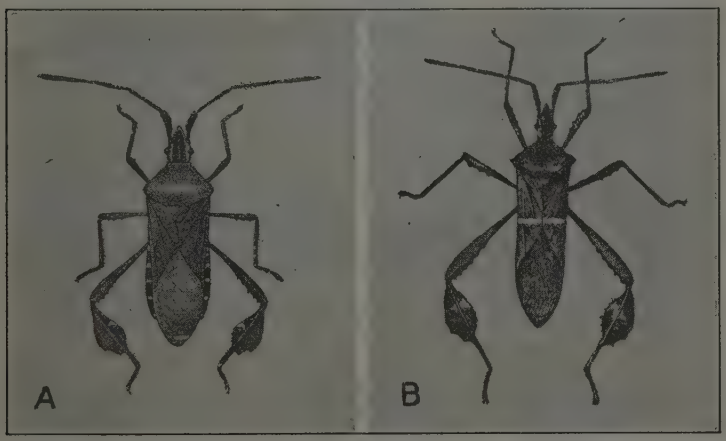

FIGURE 21.—A, Leaf-footed bug; B, northern leaf-footed bug. Enlarged 2 diameters

summer months they hatch in five or six days. The number of eggs in a cluster has ranged from 36 to 116. The young bugs molt five

times before attaining full growth, and with each molt they take on a marked variation in color pattern. It is very probable that this species may develop four full generations annually in the extreme southern portion of the pecan belt.

FOOD PLANTS AND FEEDING HABITS

The southern green stinkbug is one of the most widely distributed insects known to science and infests a wide variety of plants. It is

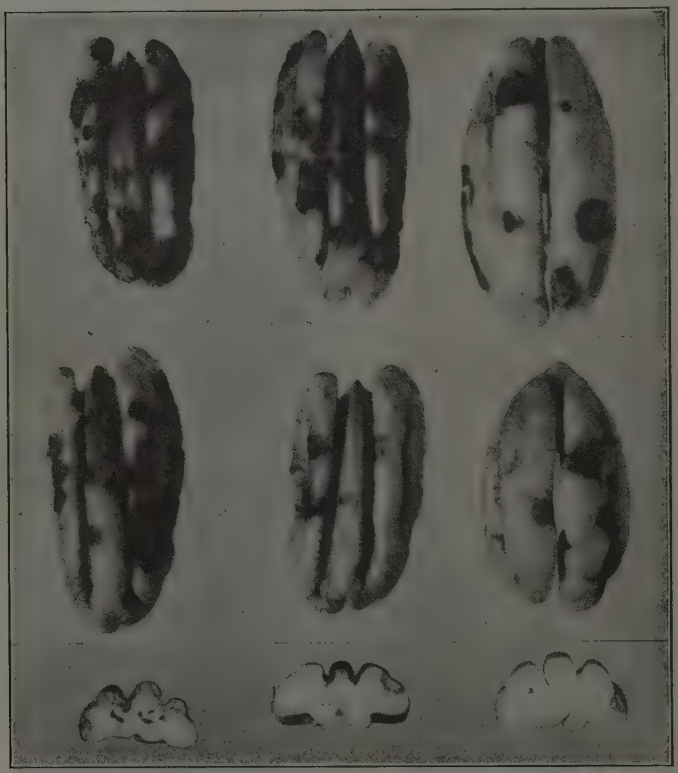

FIGURE 22.—Kernel spots on Schley pecans. The upper and central views show the location of the spots on the ridges and edges of the pecan halves. The three lower views of kernels, cut through the spots, show the depth and extent of the injury

found in nearly all of the tropical and subtropical countries of the world, extending well up into the temperate regions; in the United States it is spread through the southern tier of States from South Carolina to California. The list of recorded hosts covers such diversified plants as corn and artichoke, sandspur and sunflower. There are included a number of trees, though the species is primarily herb-

infesting and is generally known as a pest of truck and cover crops. Members of the mustard family, including collards, mustard, and radish, and members of the pea family, including beggarweed, rattlebox, coffee weed, and cowpea, are the most attractive to this insect.

Like all others of the large group of insects called plant bugs, the southern green stinkbug feeds by piercing a plant with its strong sharp beak and sucking the plant juice. It is unable to take food from the surface and furthermore is unable to eat any but liquid food.

Two other points about the feeding of this insect are important. The bug distinctly prefers growing tips and the soft pulp of an immature seed pod or fruit to the harder parts of a plant. Accordingly many fruits in the tender stage may be attacked.

The second point is that of the number of plants on which the species feeds only a few are breeding hosts, that is, plants on which eggs are laid and the young develop. Other plants, such as the pecan, are attacked only by the adults which fly from these breeding hosts.

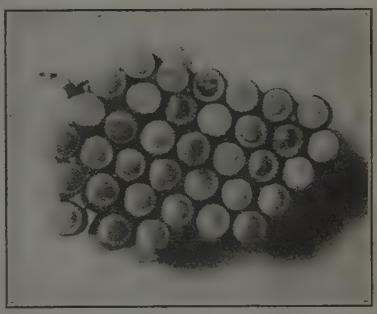

FIGURE 23.—Egg cluster of southern green stinkbug viewed from above. Enlarged 6 diameters

CONTROL

Natural factors, including low temperatures and insect enemies, help in keeping the southern green stinkbug in check. The pecan grower must not rely on these factors, however, to protect pecans from kernel spot or black pit. The growers of truck crops may resort to contact insecticides, hand picking, and trap crops, but these are not readily applicable to conditions of pecan culture. To the pecan grower is suggested the proper use of cover and intercrops and the sanitation of orchards.

Clean cultivation, a practice which would aid in the control of the stinkbug, can not be recommended in pecan orchards, because the soils need organic matter which may be maintained by the use of green cover crops. Cowpeas have long been commonly used to provide the much needed humus; but the cowpea is a favored host of the stinkbug, and the worst outbreaks of kernel spot have been reported from pecan orchards planted to cowpeas or adjacent to large fields of cowpeas that have been cut for hay. The soybean is unsafe to use for the same reason, and neither should be planted in a bearing orchard. The bugs fly from the hardening bean pods to the trees, where they feed on the nuts. Fortunately the velvetbean is known to be practically free from the attacks of this insect and therefore can be safely used among pecans.

Many of the hibernating adults can be killed by thorough sanitation in winter. This applies to certain other pests also and is good orchard practice. Fence rows particularly should be cleared. Burn plant refuse such as corn and cotton stalks, pecan shucks, nuts and

leaves, dead weeds, and grass in which the insects hibernate. Late in the winter destroy mulleins, wild mustard, and any other green plants that harbor the early feeders. Kernel spot and black pit may be prevented by eliminating from pecan orchards and their vicinity the plants in which the bugs breed.

Since the species of plant bugs closely related to the southern green stinkbug, which likewise cause black pit and kernel spot, have breeding habits which correspond to some extent, the control measures which apply to the southern green stinkbug may be employed

FIGURE 24.—Injury to young pecan buds in spring caused by larvae of the pecan leaf case-bearer

against them. It may be added that various plants, such as jimson weed, yucca, basketflower, and thistle, have been found to serve as breeding hosts of these plant bugs, and wherever they are found growing efforts should be made to eliminate them from the orchard.

INSECTS INJURING THE FOLIAGE AND SHOOTS

THE PECAN LEAF CASE-BEARER

The pecan case-bearer (*Acrobasis palliolella* Rag., formerly erroneously called *Acrobasis nebulella* Riley), which is found in very injurious numbers in orchards in the southern portion of the pecan-growing area, extending from Florida to Texas, is one of the worst

pests affecting the culture of pecans. Although this insect has been reported definitely from practically all of the Southern States in which pecans are grown, it probably ranks as a serious pest only in Florida and the southern parts of Georgia, Alabama, Mississippi, Louisiana, and Texas.

This insect occurs also in some of the Northern and Middle Western States where the pecan is not grown, and here it subsists on various hickories. Generally speaking, the pecan leaf case-bearer is distributed over approximately the same territory as are its preferred hosts, namely, the pecan and hickories. Evidently certain climatic factors limit the destructiveness of this species, and because of these conditions it has not been able, apparently, to become a pest in the northern part of the pecan-growing area.

FIGURE 25.—Injury to pecan foliage and flowers by larvae of the pecan leaf case-bearer

The most serious damage by the leaf case-bearer is done during the early spring and is inflicted by the worms, which emerge from their winter cases and feed voraciously upon the unfolding buds and leaves. (Fig. 24.) These worms or larvae are small and dark brown at this time, but soon change to dark green as they feed upon the foliage. Upon leaving the winter cases the larvae enter the buds at the tips and partake of their first meal after having spent several months in hibernation. On badly infested trees the buds and tender leaves suffer serious injury (fig. 25), and often the foliage is consumed by the larvae as fast as it puts forth. It is not unusual to see pecan trees kept in a defoliated condition for weeks during the spring by the attacks of this insect. (Fig. 26.)

Since the larvae are not at all discriminating in their feeding habits, devouring the blossom buds as well as the leaf buds, they are capable of greatly reducing the yields of nuts for the current season, besides leaving the trees in a more or less weakened condition.

DESCRIPTION

As is the case with all moths, the pecan leaf case-bearer has four distinct stages; namely, egg, larva, pupa, and adult or moth. The

moth (fig. 27) measures about two-thirds of an inch across the expanded wings and presents a wide variation in color. The head, thorax, and base of forewings and legs are snow white in the males, but in the females these parts are dusky gray. The abdomen is whitish, marked with brown. The outer two-thirds of the forewing is gray, with blackish blotches or spots, which are somewhat variable, and not far from the base of the forewing is a reddish-brown stain.

FIGURE 26.—Pecan tree defoliated by the pecan leaf case-bearer

The egg (fig. 28) is oval and white, with a slight greenish tinge.

The larva (fig. 29), which is the form that inflicts the injury to buds and foliage, is a dark-green, cylindrical worm measuring a little over one-half inch in length when fully grown. The head is rounded, shiny dark brown or black. The general color of the body is a very dark green, excepting the part immediately back of the head, which is somewhat lighter. The skin is much wrinkled into folds, and the entire body is sparsely covered with fine long hairs.

The pupa (fig. 30), to which the full-grown larva changes, is of the usual form and without conspicuous markings. When first formed it is fairly dark brown, with a tinge of olive green, but later it turns to a deep, shiny, mahogany brown. The pupa is formed within the larval case.

FIGURE 27.—Moth of the pecan leaf case-bearer. Enlarged 3 diameters

SEASONAL HISTORY AND HABITS

Only one generation of the pecan leaf case-bearer develops during the course of a year, but more or less variation exists in the development of the different stages. For instance, from material under

observation during the season of 1913 it was found that the moths, numbering in all 269, emerged from May 9 to July 12. In 1914 the dates of issuance for 385 moths ran from May 15 to August 5, and in 1915 the dates at which the 591 moths emerged were from May 22 to July 23. For the three years the time of greatest or maximum emergence was the same, being the latter half of June. Because of the wide variation in moth emergence a corresponding variation occurs also in the time of egg laying. Eggs are deposited always on the underside of the leaves and usually near the junction of a vein with the midrib. (Fig. 28.) The egg stage has been found to last from six to nine days, the average being seven days. The eggs hatch from about the middle of May until the latter part of July or the first few days in August, depending more or less upon weather conditions. When the young larvae gnaw their way out of the eggshells they commence feeding upon the portion of the leaf where eggs were laid.

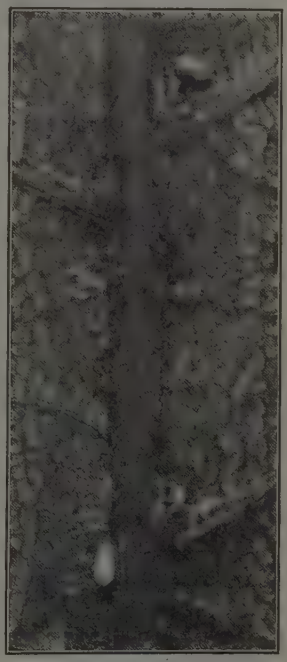

FIGURE 28.—Eggs of the pecan leaf case-bearer along midrib on lower surface of a pecan leaf. Enlarged 12 diameters

Throughout the summer and early fall the larvae feed very sparingly upon the foliage, and as they extend their feeding area they enlarge their little winding cases (fig. 31), which afford very good protection for them. Although they may feed for nearly three months, or even longer in some instances, they rarely attain a length greater than one-sixteenth of an inch by fall. During the latter part of September, or shortly before the leaves begin to drop, the little larvae begin to seek winter quarters around the buds, and here they construct small, compactly woven, oval cases known as hibernacula (fig. 32), and by the middle of October practically all larvae have left the foliage and are to be found snugly protected in these cases. They remain in hibernation until the latter part of March or the first

FIGURE 29.—Larva and case of the pecan leaf case-bearer. Enlarged 2 diameters

part of April, at which time the buds on pecan trees usually begin to open.

Just as the buds are opening the larvae emerge from their winter cases and attack the unfolding leaves. Their pernicious feeding habits at this time result in serious injury to the foliage and in greatly reducing the yield of nuts. The larvae feed voraciously during the spring and some of them reach full growth as early as the last days of April, but the majority do not attain full growth until May or early in June.

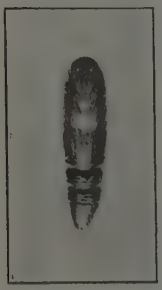

FIGURE 30.—Pupa of the pecan leaf case-bearer. Enlarged 2½ diameters.

The larvae always transform to pupae within their cases (fig. 33), and just before pupating they spin a flimsy layer of silk over the free ends of their cases. The pupal period has been found to range from 16 to 23 days, the average being a trifle over 17 days. The first adults make their appearance about the middle of May and moths continue to come forth until the first week in August. Thus the life cycle of this insect, which it will be seen covers the entire year, is completed.

FIGURE 31.—Injury to lower surface of pecan leaf by newly hatched larvae of the pecan leaf case-bearer. Enlarged 2½ diameters

CONTROL

Although the pecan leaf case-bearer is attacked by a number of parasitic insects, it has been found that the parasitic or other natural enemies can not be relied upon to control this pest, but artificial measures of control can be instituted successfully and practically to check its ravages. A mite (*Pediculoides ventricosus* Newp.) often destroys many larvae in the spring during dry seasons. Three species of birds—the blue jay, the mocking bird, and the orchard oriole—have been observed feeding upon the larvae.

Investigations have shown that the pecan leaf case-bearer can be controlled by spraying with calcium arsenate. This should be used at the rate of 1 pound to 50 gallons of 3–4–50 Bordeaux mixture.

Under no circumstances should calcium arsenate be used without Bordeaux mixture, as more or less serious injury to the foliage or nuts is likely to result. Arsenical injury has not been noticed on pecan trees where calcium arsenate is used in combination with Bordeaux mixture, as used in the last application for pecan scab on scab-susceptible varieties or when Bordeaux mixture is used on pecan trees against leaf blotch or brown leaf spot.

Only one thorough spraying is necessary to control this pest. This should be applied at the time of the last Bordeaux application for pecan scab, leaf blotch, or brown leaf spot about July 15.

In spraying it should be borne in mind that only the larvae that have fed on the poisoned foliage will be killed. Growers should realize the importance of spraying at the proper time and apply the poison thoroughly to all parts of the foliage, especially the underside, upon which the larvae are feeding.

Dusting for the control of the pecan leaf case-bearer is not recommended, as very unsatisfactory results have been obtained in experimental work in the use of dust mixtures.

FIGURE 32.—Winter cases of pecan leaf case-bearer around pecan bud. Enlarged 7 diameters

THE PECAN CIGAR CASE-BEARER

The pecan cigar case-bearer (*Coleophora caryaefoliella* Clem.) is usually considered a pest of only minor importance, but reports have been received of its occurrence in injurious numbers in pecan orchards during the spring months and of the infliction of serious damage to the buds and foliage. (Fig. 34.) This insect does not confine its attacks to the pecan, as it feeds upon the various species of hickory and the black walnut. The pecan cigar case-bearer is distributed over a wide range of country, extending from Florida to the extreme border of Texas and as far north as New Hampshire. When the buds of the pecan are opening, or just after they have begun to unfold, the hibernating larvae become active and attack them, continuing their feeding operations on the foliage (fig. 35) until about the middle of May (in Florida), when they become full grown and transform to pupae within the lateral cases. (Fig. 36, *b* and *c*.) The pupal period lasts about two weeks, and during June the moths (fig. 36, *a*) appear in numbers on the pecan trees.

The eggs are deposited on the foliage and hatch within a few days. Upon emerging the larvae feed first as leaf miners, but later in the season they construct the small cases, in which they feed upon the leaves until a short time before the foliage drops in the fall. The larvae then migrate to the twigs or larger limbs or trunks, where they attach their cases and spend the winter.

CONTROL

This species is rarely abundant enough in orchards to call for special treatment. In pecan orchards in which spraying is directed against the more injurious pests the pecan cigar case-bearer rarely will be a source of trouble, as the larvae of this and the other species are killed by the same treatments. If this insect becomes abundant in the spring, calcium arsenate should be used at the rate of 1 pound to each 50 gallons of 3–4–50 Bordeaux mixture as applied for the first scab application.

FIGURE 33.—Larvae of the pecan leaf case-bearer in their cases and injury done to pecan leaflets

THE PECAN BUD MOTH

The pecan bud moth (*Gretchena bolliana* Sling.) at times becomes so abundant that the damage caused by the larvae feeding upon the terminal buds of pecan nursery stock entails considerable loss to nurserymen. This insect evidently occurs throughout the pecan-growing region, as reports of damage have been received from most of the Southern States. Besides feeding upon the pecan, it has been recorded doubtfully on various hickories and the black walnut.

DESCRIPTION

The moth is gray, mottled with blackish-brown patches and streaks, and the expanse of the wings is just a little more than half

an inch. The blackish-brown patches on the forewings are arranged in a zigzag fashion from the base of the wing to the tip. The hind wings are without markings and are dusky gray, with the outer margin somewhat darker. The moths are very active, but are often found resting on the tree trunks. When disturbed the moth will fly in a jerky manner for a short distance and then suddenly wheel about to return to the tree trunk that it just left.

The eggs (fig. 37) are small, oval, whitish, and iridescent in some lights. When the trees are in foliage the eggs are laid upon either

FIGURE 34.—Pecan tree almost defoliated by the pecan cigar case-bearer

the upper or lower surface of the leaves, but before the buds push forth in spring the eggs are often found deposited on the twigs.

The full-grown larva (fig. 38, right) is about five-eighths of an inch in length. The body, which is sparsely covered with fine hairs, is yellowish green, and through its semitransparent skin can be seen the brownish contents of the alimentary canal. The head and cervical shield, or neck, are shiny dark brown in color in full-grown larvae; but on very young larvae they are jet black.

The pupa (fig. 38, left) is light brown and varies somewhat in size, but is rarely more than one-third of an inch long. The pupae

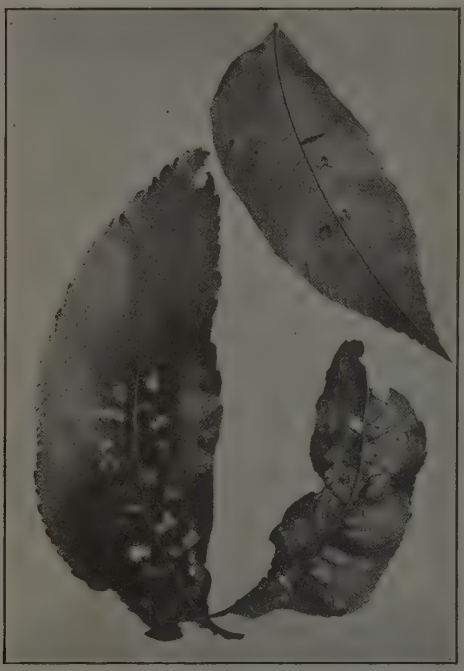

FIGURE 35.—Pecan leaves injured by larvae of the pecan cigar case-bearer

usually are formed in rolled-up leaves or infested buds, but occasionally they can be found under bark scales or at the crown of the tree.

SEASONAL HISTORY

The number of generations a year varies somewhat in different sections. In the extreme southern portion of its range, five or six occur during the course of a season. The pecan bud moth passes the winter in the adult stage. As soon as the buds on the pecan trees begin to open, the moths commence to lay eggs, usually on the branches near the buds, but after the foliage appears the eggs are laid invariably on the upper surface of the leaves. The eggs hatch in from 3 to 6 days, depending upon the temperature. The larvae feed from 21 to 29 days, the average being about 25 days. The pupal stage lasts from 8 to 13 days, with an average of 10 days.

CONTROL

Ordinarily the bud moth does not occur in sufficient numbers to be ranked as a serious pest in pecan culture. In bearing orchards it is rarely troublesome, but during some seasons it is responsible for considerable damage to nursery trees. This species is primarily a bud feeder, and in attacking the terminal buds on the young pecan trees it causes a stunted growth as well as excessive branching. This feature is

FIGURE 36.—The pecan cigar case-bearer: *a*, Moth, enlarged 8 diameters; *b*, larva in case, enlarged 6 diameters; *c*, larva in case attached to twig, enlarged 4 diameters

especially objectionable, from the nurseryman's point of view, since pecan nursery stock is sold according to height. It has been observed that vigorously growing trees in the nursery usually open and unfold their terminal buds so rapidly that the larvae apparently do not have sufficient time to inflict serious damage. It has been noticed, further, that the larvae feed on the foliage (fig. 39) if compelled to do so by the rapid growth of the tree, and under these conditions they will eat the outer parts of the leaves. During dry seasons, especially in the spring of the year, pecan nursery stock grows very slowly and is seriously injured by larvae of the bud moth. As a nursery practice it is strongly recommended that the trees be kept in a vigorous growing condition by thorough cultivation and fertilization.

FIGURE 37.—Eggs of the pecan bud moth on pecan leaflet

Spraying with calcium arsenate during the spring and summer will help materially in holding this pest in check. When this insect is to be controlled the calcium arsenate should be used at the rate of 1 pound to each 50 gallons of 3–4–50 Bordeaux mixture. Calcium arsenate should never be used unless combined with Bordeaux mixture, as foliage injury might result when this insecticide is used alone or with hydrated lime. As there are several generations of this insect, and as the trees are growing continually during the spring and summer months, four or five applications should be made, timing the applications about three or four weeks apart. Nurserymen sometimes spray for the control of nursery blight, making four or five applications of Bordeaux mixture, and where the bud moth becomes serious in nurseries where control measures are used against this

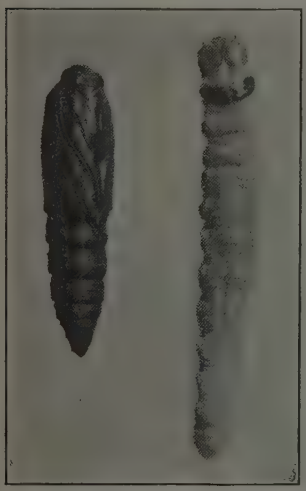

FIGURE 38.—Pupa and larva of the pecan bud moth: Pupa at left, larva at right. Enlarged 4 diameters

disease, calcium arsenate may be incorporated in the Bordeaux mixture as directed above. Observations indicate that the pecan bud moth never does sufficient damage in bearing orchards to warrant special spray applications.

MAY BEETLES

May beetles or June bugs (*Phyllophaga* sp.) are often reported as seriously defoliating pecan trees in the spring while the leaves and shoots are growing vigorously. Small trees receive the worst injury. The beetles feed at night, while in the daytime they lie hidden just beneath the surface of the ground. These insects are well known from their habit of flying to lights.

FIGURE 39.—Injury to pecan foliage by larvae of the pecan bud moth

The beetles or adults (fig. 40) are from one-half to three-fourths of an inch long, robust, and usually rich brown in color. They lay their eggs upon the soil, and the larvae, which are the notorious white grubs, burrow into the ground and spend their existence feeding upon the roots of plants, particularly grasses. Usually two years are required for development, and pupation takes place in the larval tunnel. (Fig. 41.) The adults work their way up through the soil and fly to the trees.

CONTROL

Since the young of May beetles are primarily grass feeders, they will seldom be injurious in well-cultivated orchards. Fields in the vicinity of orchards are a source of infestation, but if the soil is plowed as often as once a year the May beetles never become very numerous.

In the case of young trees, beetles may be hand picked or shaken onto sheets on the ground at night, and destroyed. They may also be caught in trap lanterns.

THE FALL WEBWORM

Perhaps the commonest insect under the observation of pecan growers is the so-called fall webworm (*Hyphantria cunea* Drury),

which constructs unsightly nests or webs over the twigs and foliage. These webs are more abundant during the late summer and fall, but since this insect has two generations in the South, the webs are to be found on pecan trees as early as May. Trees defoliated in late

FIGURE 40.—Adult May beetles. Natural size

summer frequently develop new leaves and flowers to the detriment of the crop the following year.

The moths (fig. 42), which usually are pure white but sometimes have black or brown spots on the forewings, emerge in the spring,

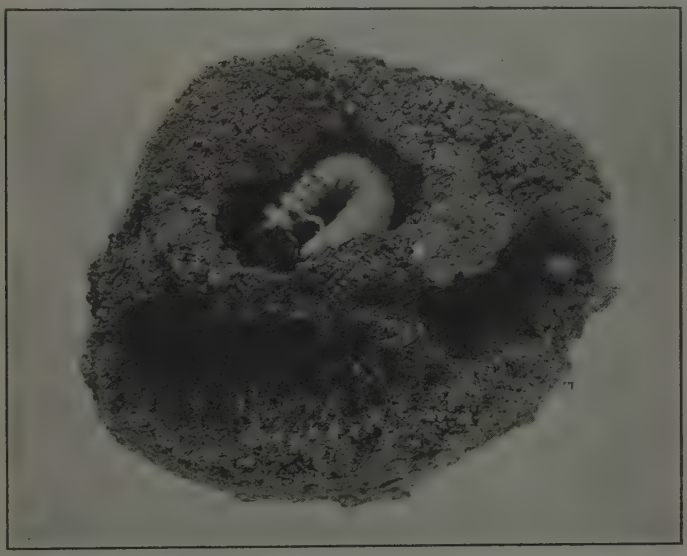

FIGURE 41.—Larva of May beetle in its cell in the ground

in April and May. The eggs are deposited in masses on the leaves, are greenish-white in color, and hatch in about a week. The larvae are gregarious, each colony forming a web in which all the caterpillars feed, eating the upper and lower surfaces of the leaves.

When they need additional leaves for food they enlarge the web (fig. 43), which may become very large and conspicuous.

The full-grown larvae (fig. 44) usually measure an inch in length, and are covered with long white and black hairs arising from numerous black tubercles. On reaching maturity they leave their webs and transform to brown pupae in flimsy, hairy cocoons beneath rubbish on the ground, under the scales of bark, or just under the surface of loose soil. The earliest date for the emergence of moths of the first generation is June 26, but most of the moths of this generation do not appear until later. The second-generation larvae have been found deserting their webs during the latter part of September, all through October, and occasionally as late as the first week in November, for the purpose of pupation. This insect passes the winter in the pupal stage, the moths appearing the following year, during April and May.

FIGURE 42.—Moth and egg mass of the fall webworm. Enlarged 2 diameters

CONTROL

When this insect is not abundant it is more practical to remove the webs from the trees by means of a long-handled tree pruner or by using a long bamboo pole. Sometimes burning the webs on the trees will be found practicable, but it should be done carefully, so that not much of the foliage will be scorched. When this insect becomes abundant, as is the case in some years, spraying with calcium arsenate at the rate of 1 pound to each 50 gallons of 3–4–50 Bordeaux mixture may be used effectively. Calcium arsenate may be incorporated in any one of the Bordeaux mixture applications as used for pecan scab during the spring or summer, depending on the severity of the attack by this insect.

THE WALNUT CATERPILLAR

In the South, branches of large pecan trees are often defoliated by colonies of a caterpillar which when full grown is black, with long whitish hairs, and nearly 2 inches in length. This is the so-called walnut caterpillar (*Datana integerrima* G. and R.). When young it is brownish, with white stripes and somewhat more hairy than the matured larva. Upon hatching from eggs, which are deposited in masses (fig. 45) on the underside of the leaves, the larvae feed at first only on the underside of the leaflets, but later they devour the

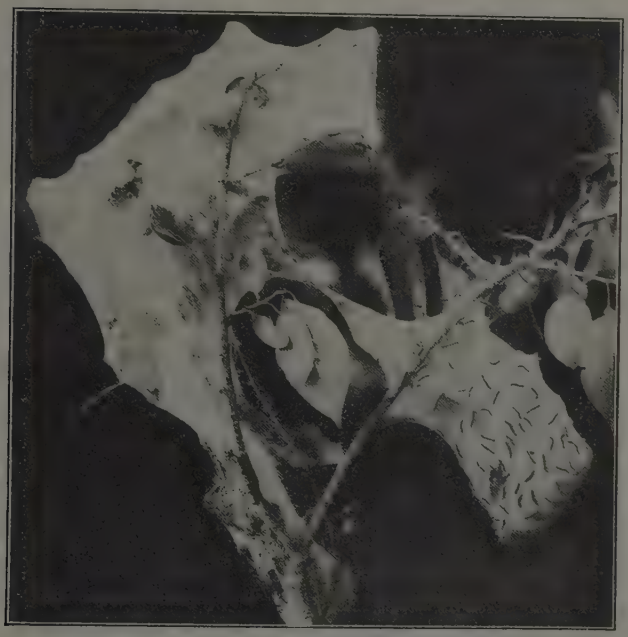

FIGURE 43.—Web and caterpillars of the fall webworm

FIGURE 44.—Portion of a web of the fall webworm showing caterpillars. Enlarged 1½ diameters

entire leaf except the midribs and petioles. Small pecan trees, especially nursery stock, are sometimes completely defoliated, and it is not uncommon to see large branches on bearing trees stripped of their foliage. The larvae feed in colonies (fig. 46), and when molting the larger caterpillars invariably leave their feeding place and crawl to the trunk or larger limbs, where in a mass they shed their skins, which may adhere to the bark for several weeks or longer. After molting they ascend the tree to continue their feeding depredations, and when full grown crawl down the trunk and immediately enter the soil to a depth of a few inches. Here, in a day or two, pupation takes place.

In the North this insect has only one generation yearly, but evidently at least two generations occur in the South.

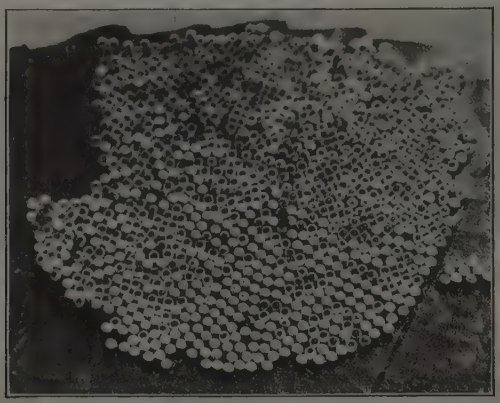

FIGURE 45.—Egg mass of the walnut caterpillar. Enlarged 2½ diameters

According to Bureau of Entomology records the moths (fig. 47) developing from overwintering pupae emerge from April 15 to July 15. Shortly after emergence egg laying takes place. The eggs, which are laid in masses of from 100 to several hundred on the underside of the leaflets, hatch in a little less than a week, and the larvae feed for 25 days or longer before completing their growth. The caterpillars enter the soil to transform to brown pupae. (Fig. 48.) Those of the first generation remain in the pupal stage about 18 days. The second-generation larvae enter the soil from the middle of September until the last week in October. They pass the winter as pupae in the ground, and the moths do not emerge until the following spring or early summer.

CONTROL

Whenever the egg masses or colonies of the caterpillars are discovered they should be promptly destroyed. In some seasons the egg masses of this species are highly parasitized, and the parasites aid materially in keeping the pest in check. The larger larvae may often be found massed on the tree trunks in the act of molting,

and these should be destroyed by crushing or by some other suitable means. Pecan orchards sprayed with such arsenicals as are used against the pecan leaf case-bearer and similar insects will rarely suffer serious damage from the walnut caterpillar.

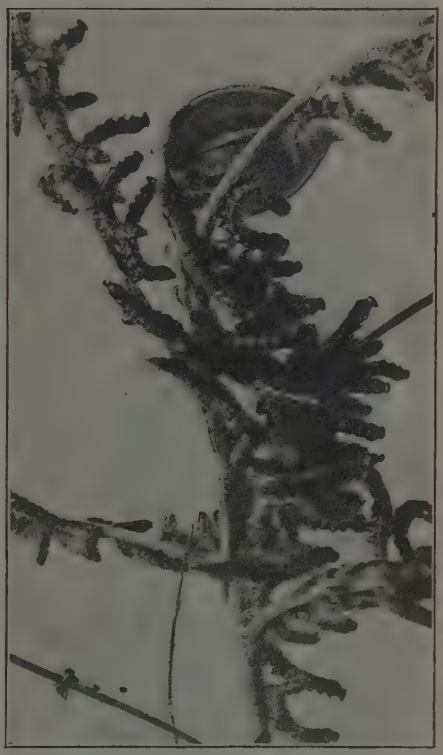

FIGURE 46.—Colony of walnut caterpillars on pecan twig

PECAN APHIDS

In midsummer the leaves of pecan trees are often found coated or spotted with a sticky glistening liquid commonly called honeydew. This substance is produced by aphids, or plant lice, which are small sucking insects. As they feed for the most part on the underside of the leaves this liquid drops to the tops of the leaves below. Later a fungus growth develops in this honeydew, causing the foliage to appear black and sooty.

There are four kinds of aphids commonly occurring on pecan and they can readily be distinguished. Only one of these, the black pecan aphid, seems to be harmful. They feed on various species of hickory, besides pecan, and are found generally distributed over the eastern half of the United States.

FIGURE 47.—Adult, or moth, of the walnut caterpillar. Enlarged 2 diameters

THE BLACK PECAN APHID

The black pecan aphid (*Myzocallis fumipennellus* Fitch) has attracted attention as a pecan pest only in recent years, though it has long been known to occur on hickory. It was originally reported on pecan from western Texas and now occurs through the Gulf States and North Carolina. It causes a conspicuous discoloration of the leaves and may cause defoliation.

The black pecan aphid will be recognized in all stages by its dark body. It is one-sixteenth of an inch long and rather robust. Its back bears a number of tubercles and is decorated with white dots of wax. The adult summer female has two pairs of wings. Its young are wingless.

In the spring young aphids hatch from overwintering eggs and move to the newly opened leaves. Here they feed and become adult aphids, all of which are females capable of producing live young without the intervention of males. At least 20 consecutive generations of these females may be produced during the summer in southern Georgia. About the middle or last of October, when the leaves begin to fall, sex forms appear, winged males and wingless females, which mate on the leaves. After fertilization the females travel downward on the trunks and deposit from 15 to 20 eggs in small crevices in the bark.

FIGURE 48.—Pupa of the walnut caterpillar. Enlarged 3 diameters

The adults are quite active and readily jump when disturbed. The young may wander some distance from their place of birth before settling down to feed; as a result they are not found in crowded colonies. Adults and young live on the under surfaces of the leaves, though occasionally they feed on the upper surface.

The black pecan aphid is notable for the marked effect of its feeding on the foliage. Soon after the young or nymphs start sucking juice, bright yellow blotches develop around the punctures and grow till about one-fourth of an inch across. (Fig. 49.) Often these blotches merge to form larger areas. The feeding of many aphids blotches the leaves so as to make them quite conspicuous in an orchard. In a short time the yellow areas turn brown and if numerous enough cause the leaflet to wither and drop. Thus a heavy infestation of the black pecan aphid may cause defoliation in the late summer.

CONTROL OF THE BLACK PECAN APHID

Applications of nicotine sulphate made in the spring after the foliage is well out and again in the late summer have given the best results. In pecan groves where the black pecan aphid continues to be instrumental in causing considerable defoliation, two applications will generally be necessary. Usually four applications of Bordeaux mixture are applied to pecans for the control of pecan scab, and since nicotine sulphate (40 per cent) is compatible with Bordeaux mixture, it may be added at the desired time. The first application for pecan scab usually is made about the middle of May. The nicotine sulphate, 40 per cent, should be incorporated in this application at the rate of 1 to 1,000 or three-fourths of a pint to each 100 gallons of the Bordeaux mixture. This early application will serve to check the insect until such time as it may be necessary

to make the second application of the nicotine sulphate. As this aphid spends its entire life on the pecan throughout the year, the suppression of the insect by one application of nicotine sulphate in the spring will not guarantee freedom from it during midsummer or late summer, and an additional application will be necessary. The second application of nicotine sulphate should generally be made with the fourth application of Bordeaux mixture as applied for pecan scab. It will largely be a question for the individual grower to decide whether under his conditions the degree of infestation is such that the nicotine sulphate should be incorporated in the third or in the fourth application of Bordeaux mixture as applied for pecan scab.

That aphids are not readily killed by a spray that does not wet them is well known. Nicotine sulphate should never be used without the addition of some ingredient which will spread it, as the effectiveness of a spray against aphids is largely dependent on its wetting capacity. Bordeaux mixture, being colloidal in nature, makes a fairly good spreader for nicotine sulphate. Whenever a pecan grower desires to control the black pecan aphid, where Bordeaux mixture is not used, nicotine sulphate should always be combined with soap at the rate of 4 pounds to each 100 gallons of the spray, to insure its spreading.

When spraying against this insect, the pecan grower should endeavor to apply the spray thoroughly to all parts of the tree and not overlook the centers. As this insect has many generations during the year, it can readily be seen that if the centers of the trees are neglected reinfestation can very easily result.

FIGURE 49.—Pecan leaflet injured by the black pecan aphid

OTHER APHIDS ON PECAN

Two yellow species, a yellow hickory aphid (*Monellia* sp., as yet undescribed, formerly erroneously called *M. caryella* Fitch), and the black-margined aphid (*M. costalis* Fitch), are often found in abundance attacking the undersides of the leaves. Though exceedingly

plentiful during the growing season, these species have never been observed to cause injury to the pecan. It may be, however, that the great quantity of honeydew, which they excrete on the leaves, interferes to some extent with the proper respiratory action of the plant.

The yellow hickory aphid is the smallest of those living on pecan. It is pale yellow with black rings upon the antennae. The young have six rows of spines down the back.

The black-margined aphid is somewhat larger than the yellow hickory aphid, flatter, and also brighter yellow in color. Its antennae are ringed in the same way. On the front and sides of the head, sides of the thorax, and front edges of the forewings is a conspicuous black line. This species is unlike any other aphid on pecan in that when resting it holds its wings flat on the back. The others

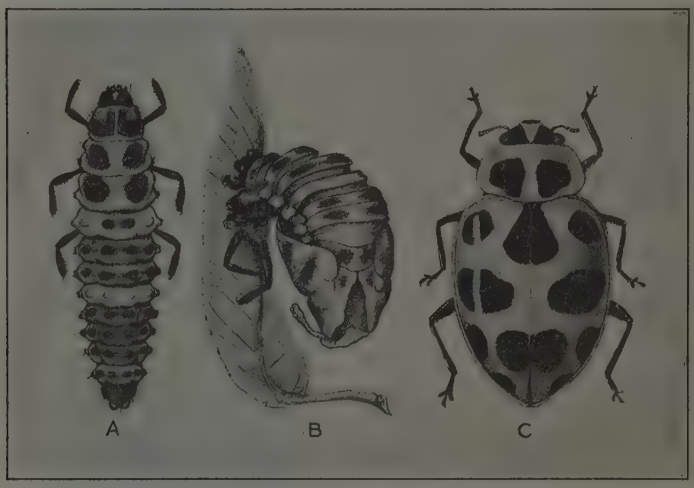

FIGURE 50.—Spotted ladybird beetle: A, Larva; B, empty pupal skin; C, adult. Enlarged 8 diameters

hold their wings upright or rooflike. The young of the black-margined aphid have four rows of spines on the back.

Both of the yellow aphids have practically the same life history as the black pecan aphid. The three species have the same number of forms and live through summer and winter in the same manner. The yellow hickory aphid is the most abundant in the spring.

The fourth species of aphid on pecan is commonly called the giant hickory aphid (*Longistigma caryae* Harris). It is found on the branches of several kinds of trees, especially on oak and sycamore and less frequently on pecan and hickory. It does not attack the foliage but obtains its food from the twigs and branches. It is one-fourth of an inch long, one of the largest aphids known. The body is gray with numerous black spots.

The life history of this large species in the South has not been fully ascertained, but it is known to feed throughout the year. On pecan it is more apparent during the cold months on the bare branches than

in the growing season. This aphid is found in crowded colonies so thick on branches that they resemble small swarms of bees.

As stated before, only the black pecan aphid has proved injurious. If the other aphids become abundant the same measures as suggested for the black pecan aphid might be tried. A heavy infestation of aphids is likely to follow the application of spray or dust for the control of other insects.

NATURAL CONTROL OF THE APHIDS

A number of predacious insects, including ladybird beetles, the larvae of lacewing flies, and one internal parasite (*Aphelinus perpallidus* Gahan), are known to attack the three smaller aphids. These cut down the numbers of aphids enormously.

The ladybird beetles are almost hemispherical in shape, one-fourth of an inch or less in length, and usually bright colored. The spotted ladybird beetle (*Ceratomegilla fuscilabris* Muls.), which has been observed eating pecan aphids, is red with black spots. (Fig. 50.) Another common one (*Chilocorus bivulnerus* Muls.) is shining black with red spots. The young of these insects are elongate and soft bodied, with long legs. (Fig. 50, A.) During the winter the adult ladybird beetles hide beneath the loose bark of trees and in piles of débris on the ground. Growers should learn to recognize these predacious insects and not destroy them, as they are beneficial.

The lacewing-fly larvae are similar to the ladybird beetle larvae with the addition of long pincherlike jaws with which to catch their prey.

Weather conditions also influence the abundance of aphids; a hot dry spell tends to increase their numbers, and cold wet weather has the opposite effect. Entomogenous fungi also play a part in the reduction of aphids. A fungus often found on the black pecan aphid is a species of Cladosporium. Aphids will be found in greater numbers on pecan trees adjacent to buildings where they are somewhat protected from wind and rain.

THE PHYLLOXERA

Pecan growers are ocasionally alarmed by the presence of tumorlike swellings or galls (fig. 51) which come on the leaves, leaf stalks and succulent shoots. These galls are caused by the attacks of a class of insects known as phylloxera (*Phylloxera caryaecaulis* Fitch, and other species), closely related to the aphids, and are in no way to be associated with a disease organism, as seems to be a more or less prevalent notion among pecan growers. An examination of the interior of a newly matured gall will reveal the true culprit in both winged and wingless or immature forms. Some species of phylloxera attack certain kinds of hickory as well as the pecan. The phylloxera is able to produce galls only on growing tissue, and hence the formation of galls is more pronounced during the early spring, although galls are found on the trees throughout the year. The young phylloxera chooses a place and commences to feed by sucking the sap from an opening leaf or fast-growing shoot. This action stimulates an abnormal plant growth which finally forms a gall and

incloses the insect. Secondary growth of foliage induced by defoliation by caterpillars is likely to be atacked by phylloxera, as well as the spring growth. Both the seedling and improved varieties of pecan are subject to attacks of these insects, but it appears that injury is much more prevalent on the seedlings. In the nursery it is not uncommon to find seedling stock covered with galls while some budded or grafted varieties growing adjacent escape injury.

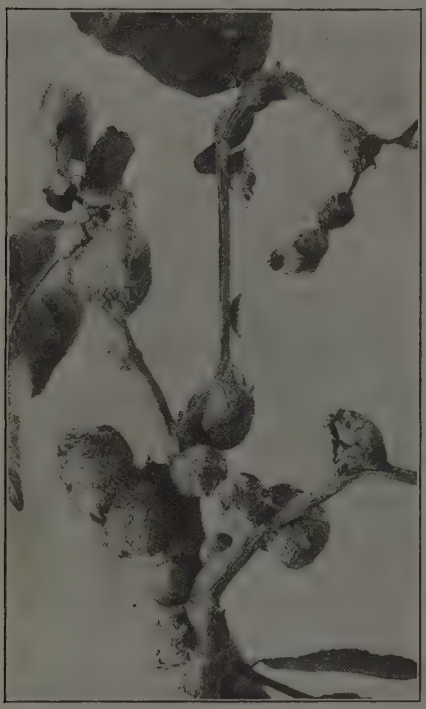

FIGURE 51.—Galls of the hickory phylloxera on pecan twig

CONTROL

Under ordinary circumstances pecan trees slightly infested by this insect will hardly demand special remedial measures. Like many other insects, this species is subject to great fluctuation in numbers, and the amount of damage therefore will vary considerably from year to year. This variation in abundance is due to the fact that the insect is held more or less completely in check by natural enemies.

So far as present knowledge of this insect goes, no very satisfactory method of control can be employed during the growing season on trees that are badly affected. It has been recommended that as many as possible of the affected leaves and shoots be clipped off by means of a long pruner before the galls open, and then be burned immediately; but this treatment will hardly prove feasible for large trees. If certain varieties of pecans show an exceptional susceptibility to infestation year after year, top-working such trees with resistant sorts doubtless would prove a practicable means of avoiding serious damage by this pest.

INSECTS INJURING THE TRUNK AND BRANCHES

THE FLAT-HEADED APPLE-TREE BORER

The flat-headed apple-tree borer (*Chrysobothris femorata* Fab.) has long been known as a more or less serious pest of certain fruit trees, such as apple, quince, pear, peach, and apricot, and among its food plants are included several shade and forest trees. This insect

is recognized in many sections of the pecan-growing belt as a serious pest of pecan trees grown under orchard conditions, and in innumerable cases its larvae have girdled and killed young trees. Its injuries are for the most part restricted to newly transplanted nursery trees and to trees devitalized by poor cultural methods or unfavorable weather conditions. Pecan trees that have been affected by winter injury or sun scald are very susceptible to the attacks of this borer. It is well known that pecan nursery stock does not stand transplanting so well as do many orchard fruit trees, as, for instance, the apple or peach, possibly because so much of the taproot is cut off in removing the trees from the nursery row. For the first year or two after being set out nursery trees make slow growth and do little more than establish themselves, even when the planting is done at what is considered the best time and with utmost care. If the spring and summer following the setting out of the young trees

FIGURE 52.—Adult beetle of the flat-headed apple-tree borer. Enlarged 3½ diameters

FIGURE 53.—A flat-headed apple-tree borer in its tunnel. Enlarged 2 diameters

are deficient in rainfall, the trees may be more or less seriously attacked by flat-headed borers, as the beetles seem to prefer to lay their eggs upon weakened trees.

DESCRIPTION

The beetle, as represented in Figure 52, is oval and flattened and about one-half inch in length, but the size is somewhat variable. The upper surface has a brownish metallic luster, the color of the underside is coppery bronze, and the part of the body underneath the wing covers is bright metallic greenish blue. The markings on the back, or wing covers, are shown in the illustration.

The larva (fig. 53) when full grown is about an inch long, without legs, and yellowish white. The second segment is much broadened and compressed, giving the larva the appearance of having a large flattened head. The larvae within their galleries always assume a curved position, somewhat as is shown in the figure.

The pupa (fig. 54) is also yellowish white, somewhat more yellow than the larva, and shows the undeveloped appendages and structures of the adult beetle.

SEASONAL HISTORY AND HABITS

The beetles are to be found from March to November in pecan orchards, but they are especially abundant at two periods, namely, during May and from the middle of August until mid September. They deposit their eggs in cracks or under bark scales upon the trunk or larger limbs. The young larva gnaws through the bark and begins to feed upon the sapwood immediately beneath, making a more or less irregular gallery packed with sawdust castings. Some galleries have a tortuous or spiral course (fig. 55), and because of this, young trees are often girdled. If the trees are able to maintain considerable vitality in spite of the attacks, the larvae do not enter the sapwood to transform to pupae, as they do in dead and dying trees, but transformation takes place immediately under the bark, a slight excavation being made in the sapwood. One year is required for the complete development from egg to adult. Because of the different sizes of larvae that may be found in trees at almost any season of the year, many growers believe that the insect has more than one generation. This, however, is to be explained by the great variation in rate of growth of the larvae and the consequent variation in time of emergence of the beetles, which takes place any time from March until early autumn.

FIGURE 54.—Pupa of the flat-headed apple-tree borer viewed from above (at right) and from below (left). Enlarged 2½ diameters

CONTROL

After borers have gained entrance to the trees, nothing better can be done than to examine the trees carefully and remove the larvae with a knife. The point of infestation on the trunk or limb can usually be detected by the discoloration and depression of the bark, which sometimes cracks open. In badly infested orchards the trees should be examined at least twice a year, and perhaps a third time would be worth while. In cutting out worms great care should be taken not to cause any unnecessary injury to the trees, and the places from which the borers have been removed should be treated with a good tree paint.

Much better than "worming" trees is to prevent infestation. Trees can be protected from egg laying by wrapping the trunks with heavy paper or burlap, which should extend from the ground to the branches and should be tied at the top and mounded with earth at the bottom. Apply the wrappers in March and remove them in November, as egg laying occurs at any time throughout this period.

In pecan orchards the use of trap logs made from newly cut branches of any favorite host plant, to attract the adult beetles for

egg laying, may be found practicable, for it is well known that this insect prefers dead or dying wood to living trees. Perhaps oak would be the best and most available wood, but hickory or pecan would serve the same purpose, as the borer breeds readily in all of them. These trap logs, from 4 to 6 feet in length and from 3 to 4 inches in diameter, should be placed at intervals of 100 feet or less during the late winter or very early spring. By smearing the logs with some lasting sticky material a good many beetles may be caught and killed. After these logs have been left in the orchard for one season they should be burned.

FIGURE 55.—Larval burrow of the flat-headed apple-tree borer in the trunk of a young pecan tree

Careful cultural methods are strongly urged as a measure of protection. Trees should not be injured by cultivating implements, as wounds so made offer attractive places for egg laying. All dead and dying trees and all pruned limbs or branches should be removed promptly and burned, for such wood affords an ideal breeding place for the borer and is therefore a menace to the orchard. The keeping of pecan wood about the orchard for future use as fuel or for other purposes is bad orchard practice and can not be condemned too strongly.

It is recommended that 1-year-old trees be planted, as such trees recover from the shock much more readily than trees which are allowed to grow in the nursery too long. In the transplanting of nursery stock to the orchard, every care should be taken to have the trees set out under the best conditions; and, judging from observations, early planting, say in December and January, and not later than February, is to be recommended, so that the trees will get the benefit of the winter rains. It is also essential that young trees be kept in a vigorous growing condition by frequent cultivation and the planting of tree rows to some suitable leguminous crop. The proper use of fertilizers also will help the trees to withstand attack of this as well as of other wood-boring insects. It is

important to remember that thrifty trees are less liable to attack than sickly or stunted ones, and injury is best avoided by the maintenance of trees in a vigorous condition of growth.

THE OAK OR HICKORY COSSID

The oak or hickory cossid (*Cossula magnifica* Strecker) in its larval state inhabits the trunk or larger branches of pecan, hickory, and oak, in which it bores or tunnels in the hard wood, making galleries several inches in length. The work of the larvae is detected rather readily by the heaps of reddish pellets of wood that collect at the base of the tree trunks. A careful examination of the affected trees will reveal the hole from which these castings are pushed out by the larvae in order that their galleries may be kept clear. The hole is about the size of a lead pencil and is closed by four flaps composed of silk and bits of chewed wood.

FIGURE 56.—Adult of the oak or hickory cossid. Slightly enlarged

DESCRIPTION

The moth (fig. 56) generally is gray, mottled with brown and black blotches, and has a wing expanse of about 1¾ inches. Each forewing has a large, light-brown patch, sprinkled at the end with dark-brown streaks. The hind wings are darker gray than the forewings and are without markings. The head is brown, the thorax light gray, peppered with faint dark spots, and the abdomen brownish gray.

The full-grown larva (fig. 57) is about 1½ inches in length. The body is pinkish in general color and covered sparsely with short fine hairs which arise from the numerous tubercles. The head, cervical shield, or neck, and plates on the hind end of the body are shiny dark brown.

The pupa, to which the larva transforms upon attaining full growth, is generally brown, except the forward part, which is blackish. On its head is a sharp projection which is of assistance to the pupa in pushing its way out of the larval burrow preparatory to the emergence of the adult moth.

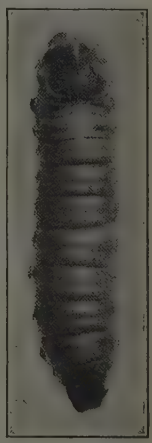

FIGURE 57.—Larva of the oak or hickory cossid. Enlarged 1½ diameters

SEASONAL HISTORY AND HABITS

The complete life cycle of this insect is not known, but it probably occupies only one year in the extreme South, and longer in its northern distribution. The moths emerge usually during May and June, and lay their eggs shortly after their appearance. The larvae upon hatching first attack small twigs, in which they tunnel out the center

or pithy wood. (Fig. 58.) When the larva has grown too large for the small twig in which it has been feeding, it crawls out and enters a larger one. By early fall the larvae will be found attacking the tree trunks or large lower branches, in which they bore into the hard wood and make their galleries parallel with the grain. At this time and during the spring months the grower can detect the castings at the base of the trees which identify the work of this insect. The transformation to pupa takes place within the larval gallery during April or May. In about one month the pupa wriggles along the tunnel to the exit hole, the moth emerges, and the split pupal case is left protruding a little from the opening.

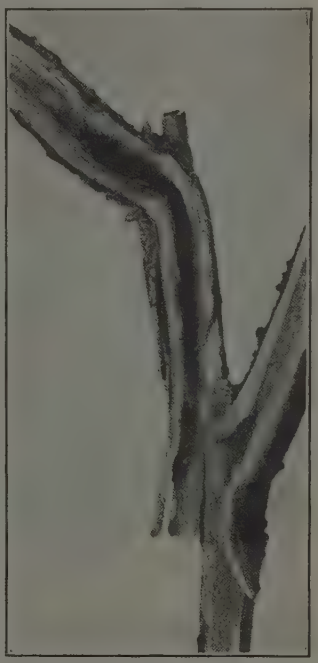

FIGURE 58.—Larval burrow of the oak or hickory cossid in pecan twig

CONTROL

All that can be done to control this insect in pecan orchards is to locate the larger limbs and tree trunks attacked, and destroy the larvae by injecting small quantities of carbon disulphide into the holes by means of a medicine dropper or oil can. The holes should then be closed immediately after treatment by means of putty, grafting wax, wooden pegs, or moist clay.

SHOT-HOLE BORERS

Small beetles called shot-hole borers (*Xylobiops basilare* Say; also species of Xyleborus) may frequently be found infesting the trunk and branches of dead or dying pecan trees. It has been observed by some that not infrequently the borers are charged with being responsible for the unhealthy and apparently diseased condition of the tree, whereas actually the diseased condition of the trunks is responsible for the presence of the insects.

The larvae bore to a considerable depth. The borings or frass of the larvae are very fine and sawdustlike in appearance, and are firmly packed or compressed within the galleries, which run with the grain of the wood. Upon attaining full growth the larvae pupate some time during the fall or spring, and the beetles emerge during the spring months. Beetles are sometimes found during the early winter in the larval galleries, in which they remain until warm weather begins. The beetles invariably make their way out at right angles to the larval galleries, and emerge through circular holes in the bark, as is shown in Figure 59.

The adult of one of the more common species is black and has small punctures over the greater part of its body. The wing covers are reddish at the base or shoulder, and at the tip or posterior end they are obliquely cut off, the edge of the cut being armed with three conspicuous teeth. This beetle is one-fourth of an inch long. Other shot-hole borers are much smaller.

CONTROL MEASURES

Since these insects attack, as a rule, only dead or dying pecan wood, they are not to be considered a serious pest. Moreover, since they attack trees in an unhealthy condition, the trees should be kept vigorously growing by practicing good orchard management. Where trees are beyond rejuvenation and the borers have become numerous, such trees or portions of trees should be removed. As a protection against shot-hole borers, as well as against the more injurious wood-boring species, all dead trees and prunings should be promptly removed from the orchard and burned.

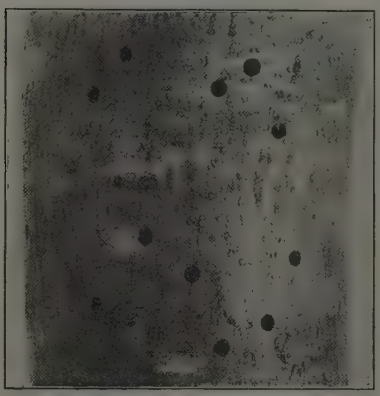

FIGURE 59.—Exit holes of adult beetles of the red-shouldered shot-hole borer

THE PECAN BORER

An insect which has been reported as attacking the pecan in North Carolina, Florida, Georgia, and Mississippi is the pecan borer (*Aegeria scitula* Harris). The work of the larvae is confined to the inner bark and sapwood, where they make winding tunnels which usually run up the trunk. This species differs from the peach borer, a closely related insect, in that it works in the trunk and branches above ground.

The feeding of a larva in the trunk of the tree is never serious, and seldom is it destructive except in young trees. In tunneling about a growing patch bud, however, the injury often becomes so extensive that the bud is girdled (fig. 60), and in other instances the buds are checked in their growth. Where large pecan trees are top worked, the buds are often seriously injured by this insect. The larvae feed underneath the bark throughout the winter.

The full-grown larva is creamy white with a reddish head and is one-half of an inch in length. The overwintering larva on reaching maturity in the spring pushes some of the frass from the tunnel through a hole in the bark and transforms to a pupa in a silken cocoon spun in a cleaned-out portion of the tunnel. On emerging the moth leaves its empty pupal case partly protruding from the tunnel (fig. 60), usually from beneath a scale of the bark. The adult (fig. 61) is one of the clear-winged moths, blue black with yellow markings. The wings of both male and female are devoid of scales

and expand about four-fifths of an inch. The moths emerge from March to the last of May and lay their eggs on the bark of the trees. The winter is passed by the larva feeding underneath the bark.

FIGURE 60.—Injury to a patch bud caused by larvae of the pecan borer. Pupal skins are seen protruding from the burrows

CONTROL MEASURES

The presence of the larvae can be detected by the reddish excrement particles protruding in small heaps from the tunnels, and the insect may be easily removed with a knife. When seedling stock is patch budded or where trees are cut back and then budded or grafted, it is advisable to examine the inserted buds in early fall for signs of this larva. It has been found that buds which are carefully wrapped with waxed tape are seldom injured.

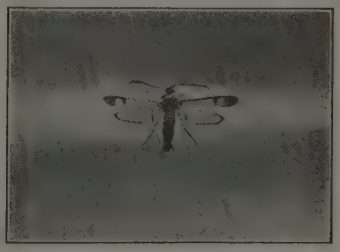

FIGURE 61.—Adult of the pecan borer

THE TWIG GIRDLER

Most pecan growers are familiar with the twig girdler (*Oncideres cingulatus* Say) which is responsible for the cutting off or pruning of pecan twigs during the late summer and early fall.

This beetle inhabits a wide range of territory, being found in most of the Eastern, Central, and Southern States, but in its more northern

FIGURE 62.—Adult or beetle of the twig girdler. Enlarged 3 diameters

distribution it does not do much injury. In the pecan-growing sections of the South it ranks as an important pest because of the excessive cutting of branches from pecan trees in orchard and nursery by the adult beetles. Besides the pecan, it has been reported as damaging the hickory, persimmon, oak, walnut, elm, maple, locust, linden, and various pome and stone fruits, including apple, pear, quince, cherry, peach, and plum, as well as orange trees and rose bushes. In the South, however, it seems to confine its attacks, for the most part, to the pecan, hickory, and persimmon.

When the beetles occur in abundance they may do much damage by severing branches for the purpose of egg laying. It is not uncommon to see the ground under pecan or hickory trees literally covered with twigs, many bearing clusters of maturing nuts, that have been cut off by the beetles, and twigs often accumulate in the tree tops in conspicuous bunches. By this cutting off of the tips of the branches the fruiting area of the tree for the following year is greatly reduced and the nut crop indirectly affected. This type of injury, besides affecting the nut production, causes the development of many offshoots, which destroys to some extent the symmetry of the tree. Pecan nurseries adjacent to a badly infested territory often suffer great loss from the girdling of the terminal branches of the trees.

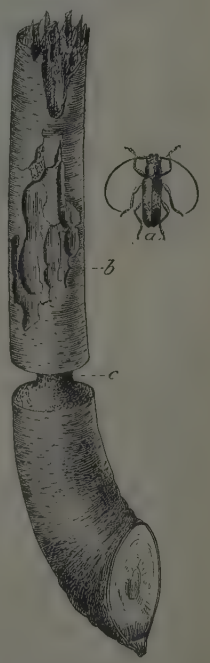

FIGURE 63.—The twig girdler: *a*, Beetle; *b*, larval mines in bark and outer wood; *c*, girdling work of adult

DESCRIPTION, SEASONAL HISTORY, AND HABITS

The beetles (figs. 62 and 63, *a*) range in length from one-half to five-eighths of an inch, the female being larger and more robust than the male. The long antennae or feelers of the male are considerably longer than the body, but those of the female are only a trifle longer than the body. The body is almost round, of a general grayish-brown color, with a rather broad, ashy band or belt extending over the middle of the wing covers. The thorax is about the same color as this band, but the head is more or less reddish.

The beetles, which begin to make their appearance in pecan orchards by the last of August or early in September, have very interesting habits. It is only the female that cuts off the twigs, but both sexes feed more or less upon the tender bark and wood of the tips. The branches apparently are girdled by the female in order that proper conditions may be provided for the development of the larvae, which are unable to subsist on wood containing sap. She does not make a complete circle at once, but cuts section by section until the entire twig has been girdled. The cut extends through the bark and well into the wood, leaving only a small portion of the heartwood untouched. (Fig. 63, *c*.) Usually the weight of the branch or the wind causes it to bend down or break off. The eggs, which are always deposited in the severed twigs, are white, oval shaped, and about one-tenth of an inch in length. They are laid during or after the cutting process, but never before the beetle has cut at least one section. They are inserted singly, beneath the bark, or slightly into the wood, near a bud scar or next to an offshoot. Usually they are deposited in the main stem of the branch, but if the branch is of good size some eggs are occasionally to be found in offshoots. After inserting the egg in the twig the beetle seals the puncture with a shiny, gummy substance, and then scars the twig for a short distance below the puncture. The number of eggs per twig may range from 3 to 40, although occasionally a severed branch without any eggs is found. The egg stage lasts three weeks.

FIGURE 64.—Pupa and larva of the twig girdler: Pupa at left, larva at right. Enlarged 3 diameters

The larvae (fig. 64, right), which are whitish, legless grubs, make little growth during the fall or winter months, but with the advent of warm weather in the spring they grow very rapidly. In making their tunnels in the twig (fig. 63, *b*, and 65) they work usually toward the severed end and feed only on the woody fibers, leaving the bark intact. During the late spring or early summer most of the larvae make a few circular holes in the bark from which they cast out pellets of borings and excrement. Just prior to transformation to the pupa (fig. 64, left) each larva closes the end of its gallery with shredded shavings, making the pupation quarters, from which the adult emerges by gnawing a more of less circular hole in the bark. Usually only one year is required for development of the insect, though some larvae do not transform until the second season.

CONTROL

For the control of this pest all that is necessary is to gather the severed branches and burn them in the fall or winter. Care should

be exercised to collect all branches from the ground, as well as those that may be lodged in the trees. By following this procedure all the eggs and larvae which would otherwise develop into beetles the following summer will be destroyed and the source of infestation eliminated. Pecan orchards that are growing adjacent to native hickory or persimmon trees will be found to be worst infested because

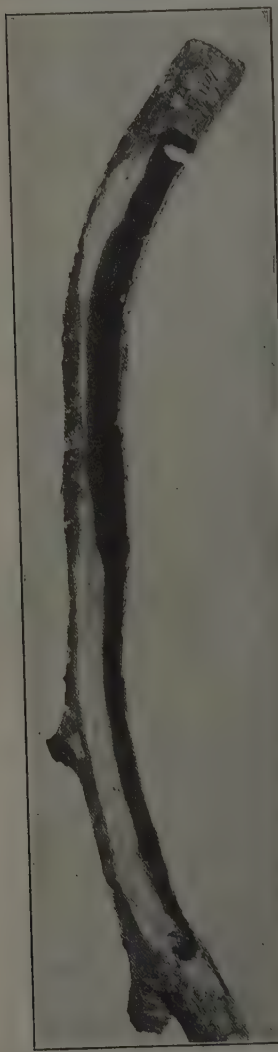

FIGURE 65.—Larval burrow of the twig girdler in cut-off pecan twig

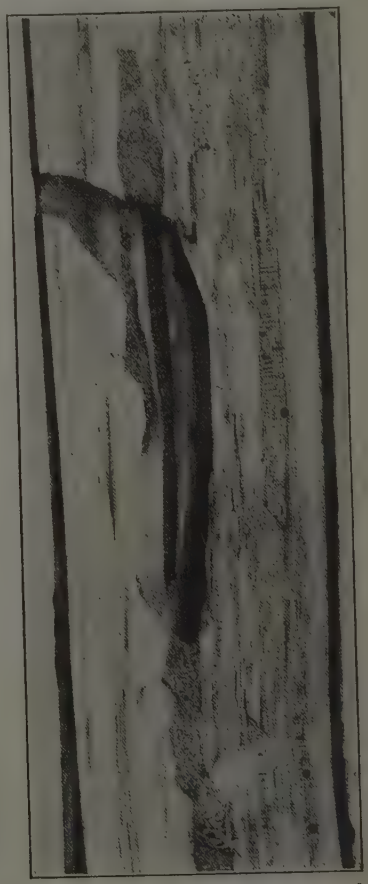

FIGURE 66.—Larval galleries of the belted chion in a pecan limb

this insect breeds abundantly in the severed branches of such trees. Under such conditions it would be well to destroy the severed

branches from the hickory and persimmon trees immediately adjacent to commercial plantings of pecans.

THE BELTED CHION

The belted chion (*Chion cinctus* Drury), in its larval state, attacks the pecan and hickories and also other trees, forming long galleries in the trunk or limbs of weakened or dead trees. The galleries (fig. 66) are excavated to a considerable depth in the heartwood, in which they run in the same direction as the grain. The larva is a yellowish-white, round-headed borer, with brown head and black jaws. Upon attaining its full development it changes to a pupa within its gallery, and the adult beetle in emerging cuts a large circular exit hole through the bark. (Fig. 67.) The beetles make their appearance any time from March to September.

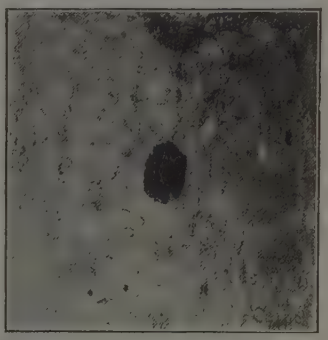

FIGURE 67.—Exit hole of the belted chion

The size of the beetles varies, the length being from two-thirds of an inch to a little more than an inch, and in the males the antennae, or feelers, are more than twice the length of the body. The color is light brown, usually with a short, oblique, dull band near the base of each wing cover, but in some specimens the bands are absent. Each wing cover bears two slender, conspicuous spines at its tip, and on each side of the thorax is a short prominent spine. (Fig. 68.)

FIGURE 68.—Adult female of the belted chion. Enlarged 2 diameters

CONTROL MEASURES

About all that is necessary to prevent injury to the pecan orchard from this pest is to remove and burn dying trees and dead wood promptly, as it is well known that this species prefers to breed in such material.

THE OAK PRUNER

During the fall and winter, twigs or branches pruned by the larvae of the dark-brown beetle known as the oak pruner (*Hypermallus villosus* Fab.) (fig. 69) are to be found under pecan trees, as well as under oak, hickory, and various other forest, shade, and fruit trees. This insect does not especially favor the pecan, but seems to show a preference for various oaks. Although it occurs from New England westward to Michigan and southward to

the Gulf States, it is seen too rarely in sufficient numbers in its extreme southern distribution to be ranked as a serious pest. In the North, however, serious injuries are sometimes caused by its pernicious pruning habits.

In the case of the twig girdler, the twigs are cut off by the female beetles, but with the oak pruner it is the larvae that amputate the branches. They do this by gnawing a circular groove in the wood, leaving only the bark intact. The branches so amputated are usually brought to the ground by the first strong wind, or, in some instances no doubt, by the weight of the branch itself. The end of the severed branch presents a smoothly cut surface (fig. 69), near the center of which will be seen a more or less oval opening plugged with fine shavings and sawdust. By way of contrast it may be stated that the end of the twig that is cut off by the twig girdler always presents at its center a more or less jagged surface.

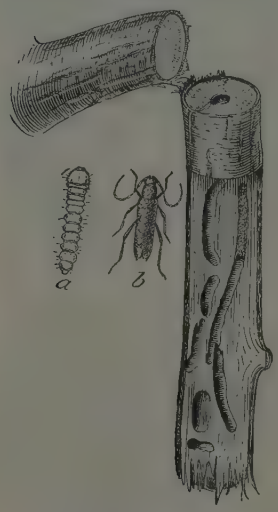

FIGURE 69.—The oak pruner: *a*, Larva; *b*, adult; (at right) cut-off twig, containing larval mines, hanging from stub of branch

The seasonal history is briefly as follows: The beetles (fig. 69, *b*) usually appear during the spring or early part of the summer, and the eggs are deposited in the leaf axils of the smaller twigs of living trees. Upon hatching, the larva feeds upon the wood immediately under the bark, but later it bores into the heartwood, where it makes an oval gallery several inches in length. (Fig. 69, right.) In the fall it cuts away the wood at the end of its gallery in such a manner that wind causes the twig to snap off. The larva (fig. 69, *a*) then proceeds to stop up the end of its channel with coarse shavings. In the larval burrow within the fallen branch the pupa is formed, either in the fall or early spring, and during the spring or early summer the beetle makes its appearance in the pecan orchards. Occasionally specimens of adults can be found in the pecan orchards as early as April.

CONTROL

The remedy for this species, like that for the twig girdler, consists in gathering the severed branches and burning them during the winter.

TERMITES [5]

Pecan trees, as well as other kinds of plants, are occasionally injured and sometimes killed by attacks of termites. (Fig. 70.) Pecan growers in certain sections are familiar with these pests under the

[5] *Reticulitermes flavipes* Kollar is the most widespread and abundant species of termite in the Eastern States.

name of "wood lice," the insects being so named because they often mine large galleries in dead wood and foundation timbers. On account of their underground habits and method of attack, termites usually escape notice until serious damage has been done, and are destroyed with great difficulty. According to reports the injury to pecan trees has been confined for the most part to seedlings 1 or 2 years old growing on recently cleared land. Sometimes young budded and grafted pecan trees are injured or killed by termite attacks, but in most, if not all, cases the orchards were set out on new land containing an abundance of dead wood.

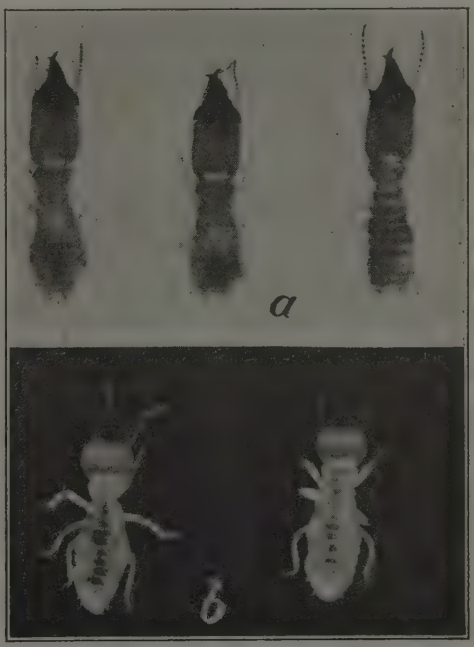

FIGURE 70.—Termites: *a*, Mature soldiers; *b*, mature workers

As is the case with true ants, termites live in colonies, and because of their similarity to ants in appearance and habits the name "white ants" has come into more or less common usage. Termites only occasionally attack living trees, their principal and most serious damage being done to foundation timbers and woodwork of buildings. In cut-over woodlands they are often prevalent under the bark of dead logs or beneath the fragments of wood lying on the ground. On small seedling trees from 1 to 2 years old the taproot frequently is hollowed until little more than a shell of bark remains. (Fig. 71.) Termites usually gain entrance to the trees below ground, but their galleries may extend for an inch or so above the soil inside the heartwood. Apparently they attack grafted trees at a point where the graft has not healed over smoothly with the seedling stock.

The affected trees as a rule do not show any indication of injury until they are damaged beyond recovery, and then they die very quickly, as is shown by the sudden wilting of the leaves.

CONTROL OF TERMITES

Because of the underground habits of termites it is difficult to apply a direct remedy to affected trees. Since they live in colonies and their nests are usually in the ground somewhere near the affected trees, it is important not only to kill the termites within the trees, but also to locate and destroy the inhabitants of the nests in order

that permanent benefit may be obtained. Nests can perhaps be destroyed most easily by pouring carbon disulphide into them and then immediately packing the soil around the nest. This is a volatile liquid, and the gas, being heavier than air, will penetrate all recesses of the nest and cause the destruction of the termites. Since carbon-disulphide treatment is somewhat dangerous to plant life, care should be taken not to use very large dosages around the trees. It should never be applied closer than about 1 foot from the trunk.

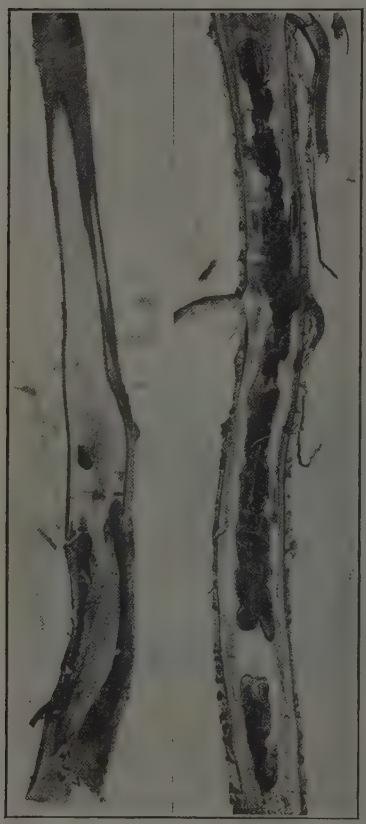

FIGURE 71.—Injury to roots of pecan nursery stock by termites

The injury to pecan nursery stock will be most serious on recently cleared land where decaying wood is abundant, as termites show a decided preference for such wood as a breeding place. As a nursery practice, for the prevention of attack by this insect, it is urged strongly that recently cleared land be avoided, but if used, all dead wood should be removed from the soil, and the growing of two or three farm crops on the land is advisable before planting the seedling nuts for the ultimate propagation of budded and grafted trees. The same advice holds true in case a young pecan orchard is to be set out, as prevention is a far more reliable method of fighting the pest than is the use of any direct remedy.

THE OBSCURE SCALE

The pecan is rather free from the attacks of scale insects, but the obscure scale (*Chrysomphalus obscurus* Comst.) has become a serious pest on both the native pecans and the cultivated varieties in Texas, Louisiana, Mississippi, and other Gulf coast districts. Besides the pecan, this insect attacks the chestnut, willow, oak, maple, hickory, grape, dogwood, wild myrtle, chinquapin, and hog plum. Occasionally trees are so badly infested that the trunks and branches are completely incrusted with this scale (fig. 72), and trees have been observed on which branches were killed. Frequently trees become so devitalized by the continued attacks of this insect that they become subject to the attacks of various borers, such as the flat-headed apple-tree borer, the cossid, and the shot-hole borers. Branches of

pecan trees are easily broken off by the wind after the combined attacks of scale and borers.

The scale has its specialized mouth parts which it inserts into the tissues for the purpose of sucking the sap. Aside from the continual drain of sap from the tree, these scales often prevent proper

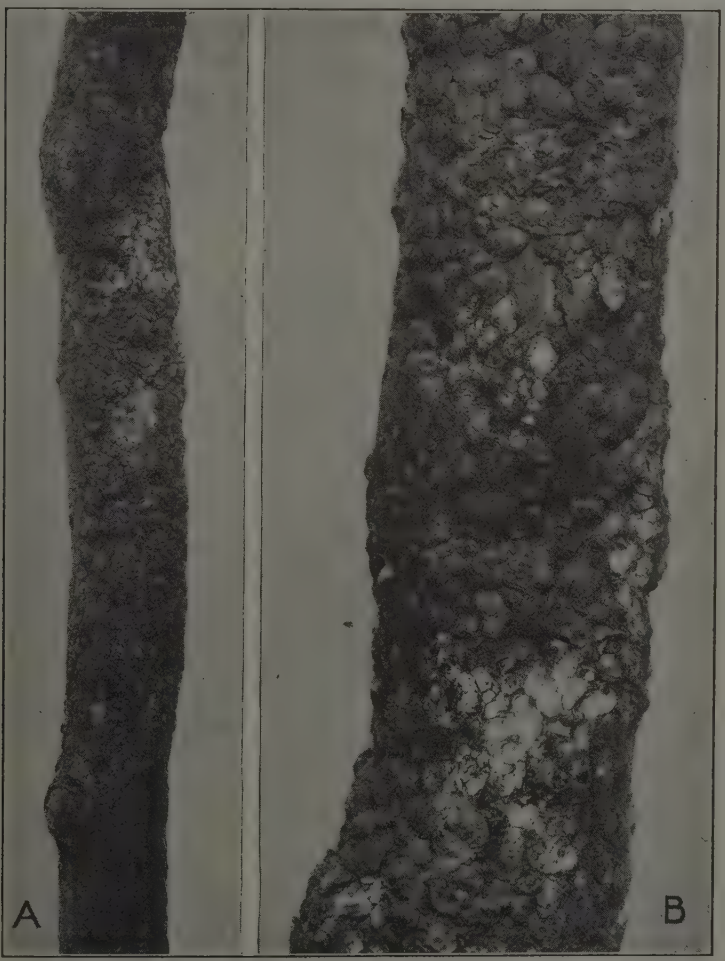

FIGURE 72.—The obscure scale on pecan twigs: A, Natural size; B, enlarged 2½ diameters

functioning by becoming so abundant as to entirely cut off light and breathing surface from the branches and trunk of the tree.

This insect belongs to a group called "scale insects" from the fact that their soft bodies are protected by scalelike coverings of a waxy material. In the case of this particular scale the covering is dark gray and approximately circular in outline. It agrees so well

in color with the bark of the tree that it is exceedingly hard to detect, hence its name "obscure scale." When it becomes very abundant on a branch, however, as is shown in Figure 72, it is readily seen.

The newly hatched larvae or crawlers are very minute and pale yellow. They are born beneath the scale which covers the adult female, and after remaining a short time they emerge, but soon settle down on some part of the tree, such as the new growth or tender twigs. Upon finding a suitable place they insert their beaks into the plant tissue to feed and start the formation of their waxy scale coverings. From this time on the female is stationary, never changing her position. During her development she molts twice, the skins so cast going to make up the scale covering. The male is at first indistinguishable from the female, but later develops two wings and issues from beneath its covering as a very small, delicate insect.

SCALE CONTROL

In localities where this scale occurs the pecan grower should examine his trees frequently for it. For this purpose he should provide himself with a small magnifying glass. Where occasional trees in a pecan orchard become infested they should be given immediate attention so that the scale will not spread throughout the orchard.

The most practical time for killing this insect on pecan trees is during the dormant season, when one or two thorough applications with a standard lubricating-oil emulsion should be made, depending on the degree of infestation. The applications should be so timed as to be a month or six weeks apart. It can not be stated definitely at what strength lubricating-oil emulsion should be applied to obtain the maximum degree of control, but some measure of success may be obtained by using an oil emulsion, made according to the Government formula, at a strength of 3 per cent of oil by volume. In order to obtain this strength 9 gallons of the concentrate should be used to 191 gallons of water.

SOME FACTORS IN SUCCESSFUL SPRAYING

Growers who contemplate spraying operations and who desire satisfactory results should make careful plans a considerable time in advance. If it is the grower's intention to purchase a spraying outfit he should not wait until the very time it is needed. If a spraying outfit is already on hand, it should be overhauled with care some time before operations begin. This will afford plenty of time to send for new parts, if any are required.

As regards the spray outfit, the tank should be cleaned thoroughly and soaked so that it will not leak. The pump and engine should be carefully repaired and worn parts replaced. It is very essential to have the valves in perfect condition to secure the desired pressure, and there may be other parts about the pump as well as the engine that need repair. If the cut-offs leak they should be replaced or ground, and nozzles, rods, or guns should be carefully examined. It is always well to have an extra lead of hose so that spraying operations will not be greatly interrupted by a leaking hose.

Pecan growers who contemplate spraying should provide themselves with a suitable power outfit, equipped with a 15-horsepower engine, a pump capable of discharging 30 gallons per minute, and

one which will maintain a pressure of 300 pounds. Spray guns are more generally used at the present time than rods for spraying pecan trees.

In spraying, the man on the ground as well as the man on the tower should aim to work half way round each tree down the row, spraying the other side of the tree on the return up the other side of the row. The spray should be applied to the tree in a systematic manner, preferably up and down, and with as little retracing as possible, to conserve materials. As to the quantity of insecticide required, successful results can not be obtained unless sufficient material is used to cover completely those parts of the tree where the insects are located. The quantity to be used will depend upon the density of foliage as well as upon the size of the trees. In spraying for any pest on pecan trees the work should be done thoroughly. For example, it is only when the leaves are hit by the insecticide that the leaf case-bearer larvae are killed; it is only when the twigs, branches, and trunks are sprayed that the scale on them is killed. In other words, thoroughness in spraying should be emphasized. Likewise the time for application is important and this should always be carefully ascertained before spraying.

SPRAY SCHEDULE FOR COMBATING PECAN INSECTS AND DISEASES[1]

Spray No. and time of application	Material	For control of—	Remarks
1. Dormant — November to January, inclusive.	Lubricating oil emulsion. Use 9 gallons of concentrate to 191 gallons of water.	Obscure scale	For light infestation make one application; for heavy infestation, two applications four to six weeks apart.
2 Immediately after pollination has taken place. The period when the tips of the small nuts have turned brown.	3-4-50 Bordeaux mixture plus nicotine sulphate 40 per cent at the rate of three-fourths of a pint to each 100 gallons of Bordeaux mixture. To control aphids on nonscabbing varieties use 40 per cent nicotine sulphate at the rate of three-fourths of a pint to 100 gallons of water plus 4 pounds of caustic potash fish-oil soap.	Scab and aphids	Both surfaces of leaves should be covered for protection against scab and to kill all aphids. For aphid control centers of trees should be sprayed as thoroughly as outer parts.
3. Three weeks after spray No. 2.	3-4-50 Bordeaux mixture	Scab	A good coverage of nuts is very important during this and all later applications. If webworms and caterpillars are abundant, add 1 pound calcium arsenate to each 50 gallons of Bordeaux mixture.
4. Three weeks after spray No. 3.	do	Scab, leaf blotch, and brown leaf spot.	Spray as directed in No. 2. If aphids are present in abundance at this time, add 40 per cent nicotine sulphate as in spray No. 2.
5. Three weeks after spray No. 4.	3-4-50 Bordeaux mixture; calcium arsenate 1 pound to each 50 gallons. Bordeaux, plus 40 per cent nicotine sulphate at the rate of three-fourths pint to each 100 gallons of the spray (add nicotine sulphate last).	Scab, leaf blotch, brown leaf spot, leaf case-bearer, and aphids.	Spray as directed in No 2.

[1] This spray schedule is designed by G. F. Moznette, entomologist, and J. B. Demaree, pathologist, to meet conditions as they exist in southern pecan orchards.

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